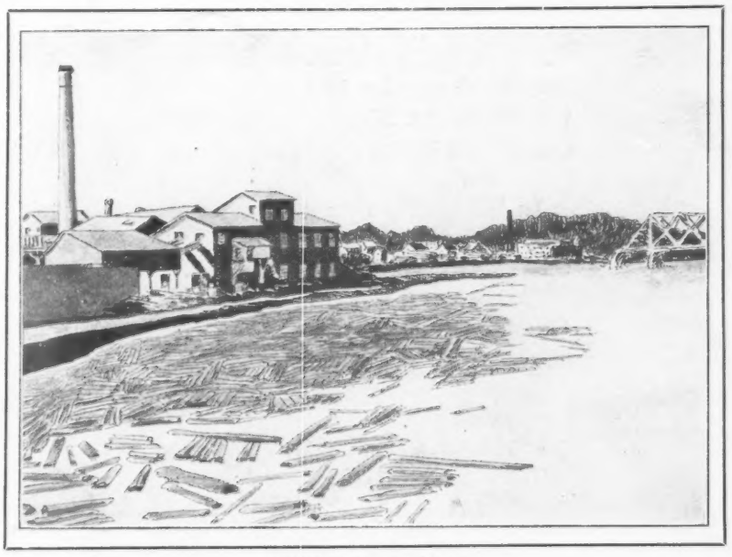
BUREAU OF STANDARDS

MAY 29 1922

LIBRARY

THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED



A Wood Pulp Mill

JUNE, 1922

VOL. III MASSACHUSETTS INSTITUTE OF TECHNOLOGY NO. 3

1/3 more per dollar

DUMORITE—the new Du Pont dynamite—is a guncotton-nitroglycerin dynamite which

1. Gives over ⅓ more work per dollar
2. Will not cause headache
3. Will not freeze in any temperature

Dumorite has approximately the same strength as regular 40% dynamite. Under ordinary conditions it does the same work, stick for stick.

40% dynamite is packed with 100 1¼ x 8 cartridges to the 50-lb. case. Dumorite has 135 to 140 cartridges to the 50-lb. case. The price is the same per case.

In Dumorite you get over ⅓ more cartridges—over ⅓ more work per dollar. In other words, your dynamite dollar is worth $1.35.

Dumorite is now being used successfully for most types of blasting work. The Du Pont Explosives Service Department is ready to work out the adaptation of this money-saving explosive to your particular operations. We suggest that you write our nearest branch office giving your requirements.

Branch Offices:

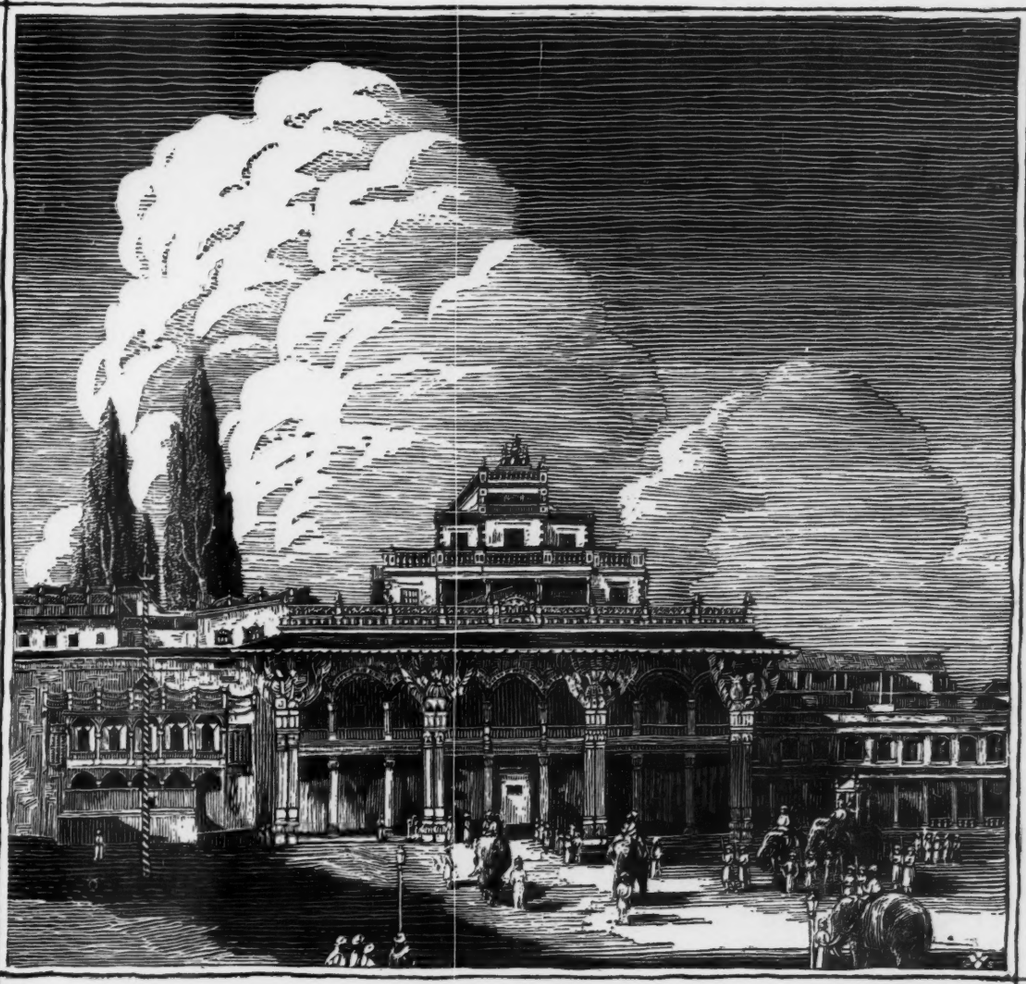
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Chicago, Ill.
Denver, Colo.
Duluth, Minn.
Huntington, W. Va.
Kansas City, Mo.
New York, N. Y.
Pittsburgh, Pa.
Portland, Ore.
St. Louis, Mo.
San Francisco, Calif.
Scranton, Pa.
Seattle, Wash.
Spokane, Wash.
Springfield, Ill.

Du Pont Products Exhibit
Atlantic City, N. J.

E. I. du Pont de Nemours & Co., Inc.
Explosives Department, **Sales Division**
Wilmington, Delaware

NON-HEADACHE DU PONT **NON-FREEZING**

DUMORITE



THE RAJAH'S PALACE
MYSORE, INDIA
Equipped with Otis Elevators

WITHIN the romantic line of "India's coral strand," in remote, unthought-of places, Otis has introduced modern, vertical transportation.

The Rajah of the native State of Mysore resides in this palace in the capital city of the same name. What a strange note this modern elevator must bring to this palace! . . . The civilization of the West reaching into the very heart of the Orient and paving the way for other products!

As an achievement, this Otis installation is noteworthy in itself, but its chief significance lies in the fact that it is a typical indication of the world-wide scope of Otis activities.

Most of the famous buildings of the world are equipped with Otis Elevators

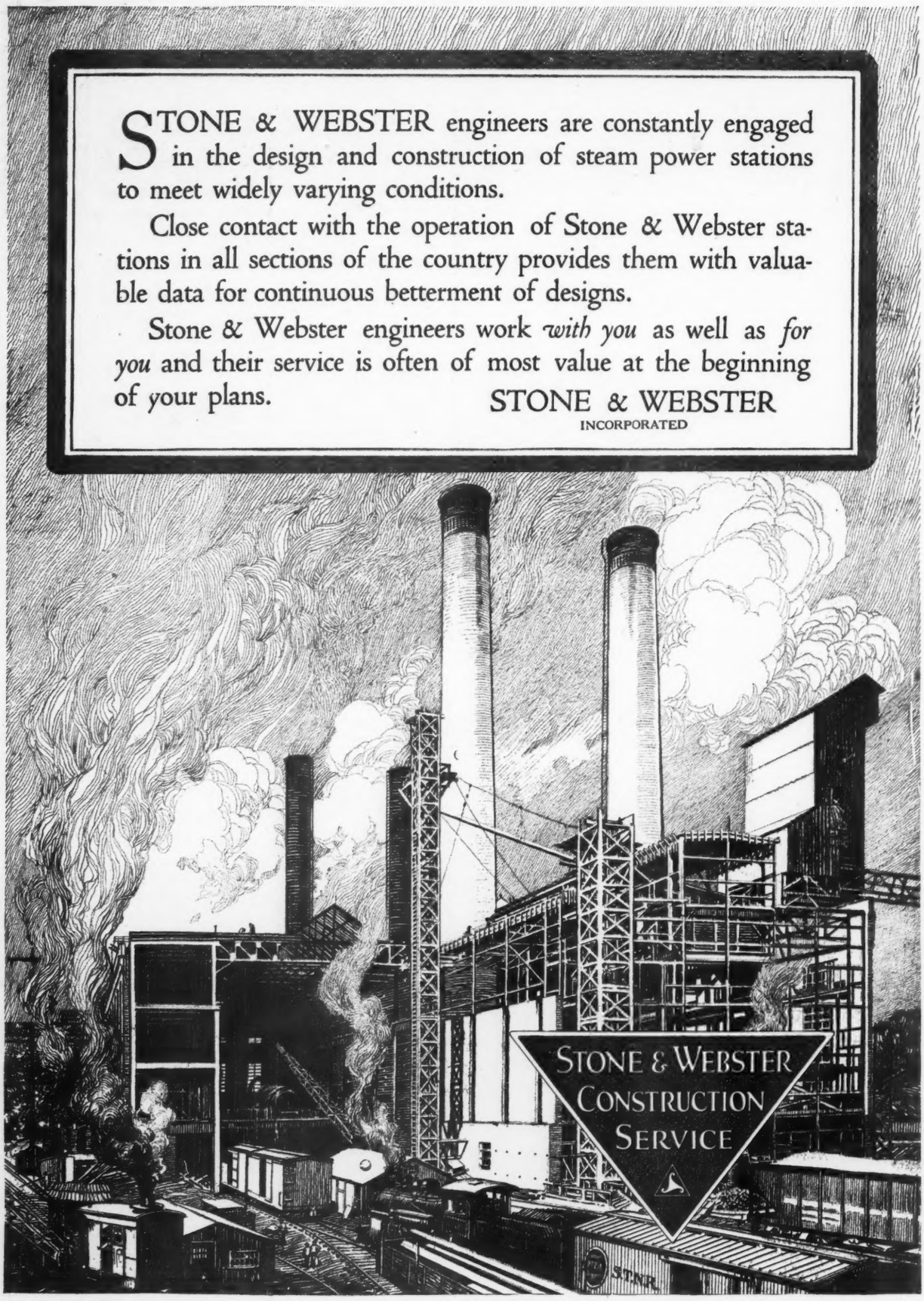
OTIS ELEVATOR COMPANY
Offices in all Principal Cities of the World

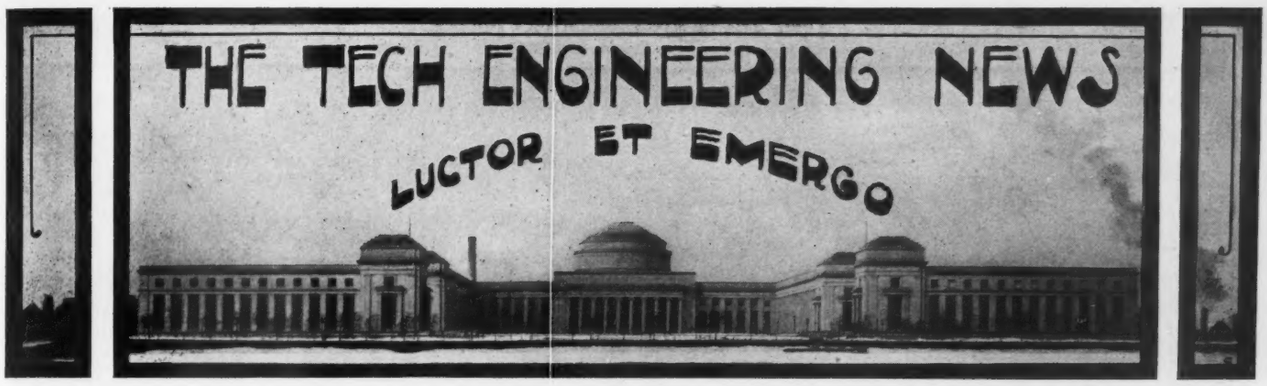
STONE & WEBSTER engineers are constantly engaged in the design and construction of steam power stations to meet widely varying conditions.

Close contact with the operation of Stone & Webster stations in all sections of the country provides them with valuable data for continuous betterment of designs.

Stone & Webster engineers work *with you* as well as *for you* and their service is often of most value at the beginning of your plans.

STONE & WEBSTER
INCORPORATED





Volume III | CAMBRIDGE, MASS., JUNE, 1922 | Number 3

Copyright 1922 by The Tech Engineering News

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer coöperation between Alumni and undergraduates. Member of the Engineering College Magazines Associated.

THE MANAGING BOARD

BENJAMIN P. LANE, *Editor-in-Chief*
FORREST G. HARMON, *General Manager*
FRANCIS P. SQUIBB, *Business Manager*
DOUGLAS F. ELLIOTT, *Managing Editor*
GASTON A. CONKLIN, *Publicity Manager*
ROBERT H. KEAN, *Assistant General Manager*
RODOLPHUS K. TURNER, *Circulation Manager*
WILLIAM F. DONOVAN, JR., *Advertising Manager*

EDITORIAL DIVISION

THE EDITORIAL BOARD

W. F. BURBANK, Assistant Managing Editor
T. B. DREW, Director of Research
B. GASSER, Features Editor
J. J. PARSONS, Undergraduate Editor
R. L. HERSHEY, Chairman Editorial Committee

Features Department
S. EMERSON
R. W. STEWART
A. J. TIGGES

Editorial Committee
H. H. SPENCER
B. L'HOMMEDIEU

Publication Department
L. F. SIMONDS
B. E. GROENEWOLD

Research Department
J. H. THOMPSON, Assistant Director
R. A. FORD
R. T. LASSITER
C. H. WARDWELL

Undergraduate Department
S. A. GUERRIERI
M. P. O'BRIEN
S. HELFMAN
J. R. ROBERTSON

BUSINESS DIVISION

THE BUSINESS BOARD

H. G. DONOVAN, Assistant Circulation Manager
C. L. PETZE, JR., Assistant Advertising Manager
B. J. STEVENS, Business Assistant
C. S. STODTER, Assistant Circulation Manager
H. D. WERNER, Business Assistant

Advertising Department
H. S. BAKER

Treasury Department
R. E. DENSFORD

Publicity Department
G. W. BRICKER, JR.
O. P. MEAKER
W. C. JOHNSON
T. E. ROUNDS, JR.

ADVISORY COUNCIL OF ASSOCIATE EDITORS
E. A. ASH
R. S. HALL
C. W. MASCHAL
J. C. PATTY
H. C. PRATT
R. A. ST. LAURENT
H. F. STOSE
B. W. THORON

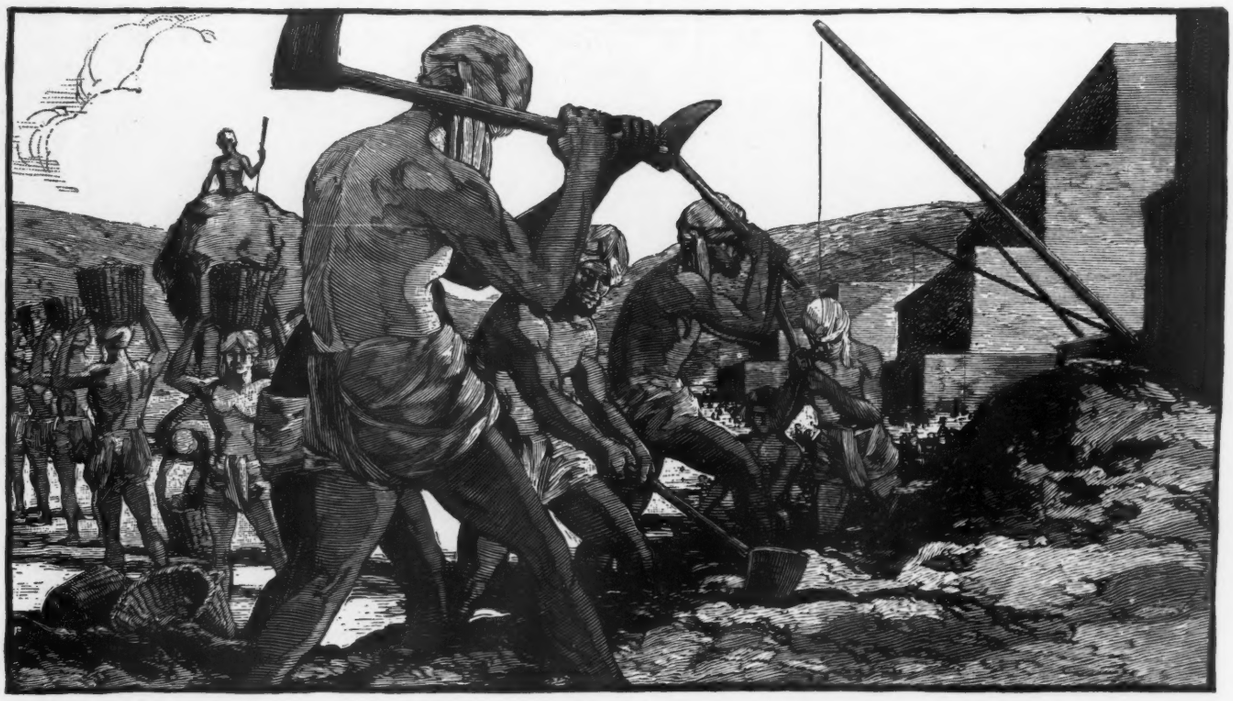
OTHER MEMBERS OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

The Transit
Iowa Engineer
Colorado Engineer
Nebraska Blue Print
Sibley Journal of Engineering
Rose Technic
Michigan Technic
Minnesota Techno - Log
University of Virginia Journal of Engineering
Ohio State Engineer
Wisconsin Engineer
Illinois Technograph
Cornell Civil Engineer
Kansas State Engineer
Princeton E. A. News Letter

Subscription, per year, $1.75 (To Technology Students $1.50) Single Copy, $.25 (To Technology Students $.20)
Address all communications to The Tech Engineering News, Walker Memorial, Cambridge 39, Massachusetts. Telephone University 6864.
Advertising rates upon application.

Table of Contents

	Page
THE NEW SHIP CRANE FOR THE NAVY. By A. F. Case	71
THE GROWTH OF HIGHWAY TRANSPORTATION. By F. W. Fenn	72
GETTING A JOB WHEN YOU GRADUATE. By William L. Fletcher	74
ELECTROCHEMISTRY IN THE WOOD PULP INDUSTRY. By Arthur B. Larchar	76
PROFESSOR HEINRICH OSCAR HOFMAN. By Prof. Carle Reed Hayward	77
PHOTO-ELASTICITY AND ITS APPLICATION TO ENGINEERING PROBLEMS By Paul Heymans	80



The Great Rajasamand Dam

The ruler of Rajputana, in the heart of India, began the great dam "Rajasamand" in 1661. This vast pile of white polished marble, hidden so well in the Aravalli Mountains, has remained almost unknown for generations. It is a colossal monument to these early engineers.

Twenty years were consumed in building the dam; hammers and chisels were used for cutting the rocks; large sharp hoes for excavating earth. Workmen, commandeered by the Rajah, moved "in that leisurely but regular procession peculiar to the East, where time is not and obedience is law".

It is doubtful whether modern engineers can build a better structure; but today they must also consider costs. Explosives have made possible the building of dams larger than Rajasamand and equally as enduring, with much less labor and in less than one-tenth the time; but even explosives—one of man's greatest cost-reducing inventions—must now be carefully compared and chosen.

For reducing blasting costs, we have for several years recommended Hercules Special No. 1. This dynamite contains nothing but the highest grade of standard materials and by wide use has proved its dependability. Special No. 1 replaces 35% and 40% cartridge for cartridge, but, because of its higher cartridge-count, costs less per cartridge than 15% dynamite. No high explosive on the market is more economical than Hercules Special No. 1.

If you are interested in the elimination of waste, write to our advertising department, 942 King Street, Wilmington, Delaware, for our booklet, Volume vs. Weight—A Lesson in Explosives Economy.

HERCULES

POWDER COMPANY

Allentown, Pa.
Birmingham, Ala.
Buffalo, N. Y.
Chattanooga, Tenn.
Chicago, Ill.
Denver, Colo.
Duluth, Minn.
Hazleton, Pa.
Huntington, W. Va.
Joplin, Mo.
Los Angeles, Cal.
Louisville, Ky.
New York City
Norristown, Pa.
Pittsburg, Kan.
Pittsburgh, Pa.
Pottsville, Pa.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Wilkesbarre, Pa.
Wilmington, Del.

Yardage, remember— first goes into the mixer!

The charging skip on a concrete mixer starts with heavy load from dead weight and elevates at high speed. Terrific strains throughout the mixer, unless the frame and super structure have heavy duty construction. Less strain on the Koehring because the Koehring skip cables get a more perpendicular "pull" —and the Koehring skip goes to the high charging angle that shoots material into the drum in a swift, clean slide, without need for pounding skip against the frame.

Koehring Heavy Duty Construction matches the operating speed of the Koehring paver—the fastest paving unit.

Capacities:

Construction Mixers: 10, 14, 21, 28 cu. ft. mixed concrete. Write for Catalog C22

Pavers: 7, 10, 14, 21, 32 cu. ft. mixed concrete. Write for Catalog P22

Dandie: Light mixer, 4 and 7 cu. ft. mixed concrete; power charging skip, or low charging platform. Light duty hoist. Write for Catalog D22

KOEHRING COMPANY
MILWAUKEE, WISCONSIN

NATIONAL U.S.A. DYES

The Romance *of* Organic Chemistry

WHEN the professor in "Chem I" gave you that greenish white salt and told you to find out what its base and acid were, he was leading you along the well beaten paths of analysis, or the finding out of what things are. This was inorganic chemistry.

Beyond that realm, fascinating as it is, stretches the mystical land of inexhaustible possibilities—the land of synthesis, or the putting of things together to make something new.

Without limit or boundary, reaching to all points of the industrial compass, the science of Organic Chemistry beckons each earnest student to discoveries which may be of inestimable value to the human race, and may enroll his name on the tablets of immortality.

National Aniline and Chemical Company, Inc.

New York Chicago Charlotte Toronto Philadelphia
Boston Hartford Montreal Providence San Francisco

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE ALUMNI AND UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME III | JUNE, 1922 | NUMBER 3

THE NEW SHIP CRANE FOR THE NAVY

By A. F. CASE, Engineer
The Wellman-Seaver-Morgan Company, Cleveland, Ohio

The Navy has recently awarded a contract for the construction of a two hundred and fifty ton revolving crane to be mounted on the hull of the United States battleship *Kearsarge*.

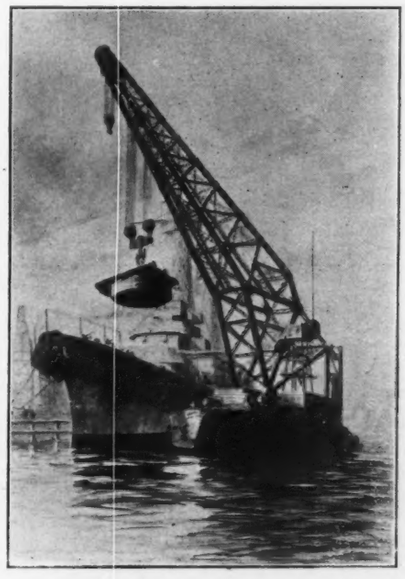
The crane will be so constructed that the crane-ship will be seaworthy, as it is the intention to transport the ship, under its own power, with turrets and guns on board, to any port where the crane service is required. This will be the largest sea-going crane ever constructed.

The construction will be under the direction of Rear Admiral D. W. Taylor, Chief Constructor of the Navy, Bureau of Construction and Repair. The crane proper will be designed and erected on the *Kearsarge* at the League Island Navy Yard, Philadelphia, by the Wellman-Seaver-Morgan Company of Cleveland, Ohio. All of the work of preparation of the hull to support the crane will be done by the Navy Department.

The battleship *Kearsarge*, with her sister ship *Kentucky*, was launched at Newport News, Virginia, on March 24, 1898, and was the first battleship to have superposed turrets. The length over all is three hundred and seventy-three feet, beam seventy-two feet, draft twenty-three feet, six inches, displacement 11,520 tons. Her indicated horse power was 11,900 and her trial speed was 16.82 knots per hour.

Preparatory to the mounting of the crane, the guns, turrets, and armor will be removed, and a circular steel foundation, sixty feet in diameter, will be constructed on the deck. To this foundation, the rails for the rotating structure will be secured; for the crane will be of the rotary, hinged jib type. Bulges will also be constructed along each side of the present hull of the *Kearsarge* to produce additional transverse stability, making a total beam of ninety-two feet.

The crane proper will consist of a rotating platform to which the jib will be hinged. The jib will be an enormous structure, even in itself, for it is required to handle its maximum loads at far reaches and great heights. Two main hoist blocks, each having a capacity of one hundred and twenty-five tons, will be suspended from the jib, side by side, from sheaves fixed in the structure. A forty-ton auxiliary block will be suspended from a trolley which travels lengthwise of the jib between the main hoists.



ARTIST'S CONCEPTION OF COMPLETED CRANE-SHIP

An equalizer, with a single hook, will be used to connect the main hoist blocks together when handling the maximum load of two hundred and fifty tons.

The jib will be capable of luffing, in a vertical plane, about its hinge pins, this motion being obtained by two massive screws which operate nuts attached to the elbow of the jib and to a steel back frame built up at the back of the rotating platform. The range of these screws is sufficient so that the jib may be luffed to all working positions and also to a position approximately horizontal, when its outer end will rest in a cradle, provided at the after end of the ship for this sea-going or transport position. After the jib has been lowered into the cradle, the entire rotating structure is locked by means of motor operated wedges, to prevent rotation. A special device will also be arranged so that the screws can be slacked off to allow the jib to rest securely in the cradle.

The rotating platform will rotate about a central pivot located within the circular foundation. A system of equalized trucks, attached to the platform, will travel on heavy rails attached to the foundation. There will be four rings of these rails, located in pairs, four feet apart and having a mean diameter of sixty feet.

Intermediate between the rails a bevel gear ring will be attached to the foundation, and meshing with this gear will be two bevel pinions which will be connected to separate driving motors on the rotating platform. These pinions will be diametrically opposite at each side of the platform so that deflections in the structure under load will not affect the mesh of the teeth.

All of the hoisting and rotating machinery will be carried on the rotating platform, ropes from the drums being led around deflecting sheaves in the back frame and thence to the hoist sheaves in the jib.

The various functions of the crane will be controlled from an operating tower located at the right side of the jib, on the rotating platform. From this station, high above the deck, the operator will hoist or lower the loads hanging on the hook blocks, move the auxiliary trolley in or out on the jib, luff the jib up or down, or rotate the

(Continued on page 85)

THE GROWTH OF HIGHWAY TRANSPORTATION

By F. W. FENN
Secretary, National Motor Truck Committee, National Automobile Chamber of Commerce

If you have been reading H. G. Wells, you will recall that in one of his characteristic articles he called attention to the fact that the development of civilization was due to two factors: transportation and communication. In his judgment these have been the vital factors that have enabled human beings to develop so marvelously and so rapidly in the last few hundred years.

Transportation over the highways is nothing new; it is merely one of the activities which we have adopted from the past. Its development has passed through many successive stages until today, with the invention and extensive application of the internal combustion engine, we find in this country over 1,000,000 commercial vehicles transporting approximately 1,430,000,000 tons of freight annually at an estimated mileage of 7,150,000,000, and over 9,000,000 passenger vehicles carrying 5,000,000,000 passengers, or nearly four times the 1,234,000,000 revenue passengers of the railroads. Also we find Congress appropriating $75,000,000 for distribution among the several states for new road construction. These figures may seem rather staggering at first reflection; let me help you to analyze the situation that has provoked the birth of an industry that today ranks first in point of volume of business among finished products, the wholesale value of its products for 1921 being $1,222,350,000.

Various methods of transportation have been employed from time to time in the handling of less than carload shipments. In the last few years, embargoes, incident to the World War, increased the cost of shipments by rail; and the delays in such transportation have resulted in switching many manufacturers, especially in New England, to the motor truck. When it is considered that the large majority of the industries in New England are located within a strip of territory fifty miles from the Atlantic Coast between New York and Portland, Maine, and that in no other section of the United States is there such a density of manufacturing with such uniformly good state highways connecting the various manufacturing communities, it will be seen that this territory is peculiarly adapted to the use of motor trucks. Behind this geographical reason for the realignment of transportation facilities in favor of the motor truck is an underlying economic trend.

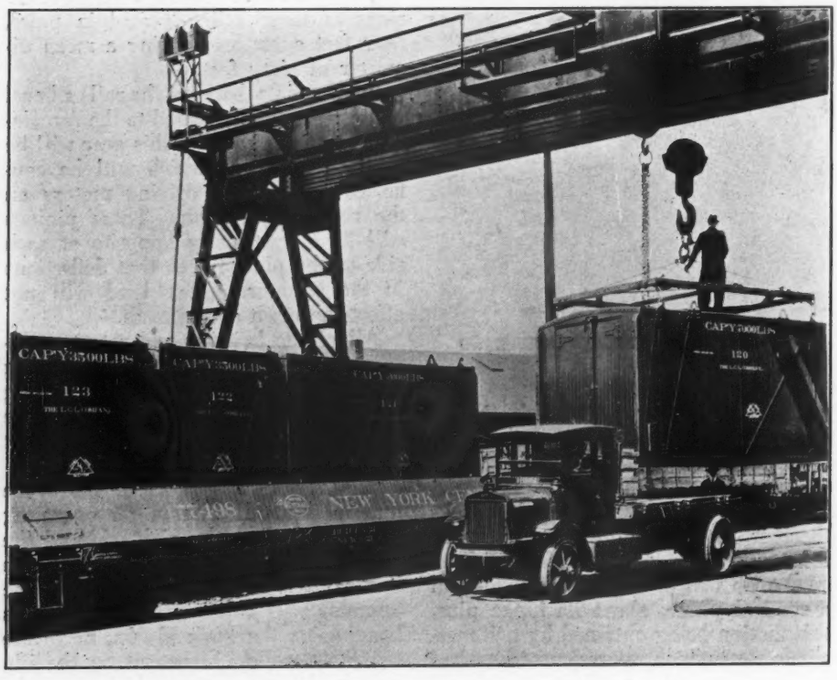
Edward Hungerford, an authority on rail freight transportation, emphatically asserts that "old-time railroaders for years past have said that a freight car did not begin to make money until it had hauled its goods at least forty miles; today the modern generation of operators will come nearer to putting this figure at eighty miles. Up to a distance somewhere between these figures —and undoubtedly far nearer eighty than forty—the vast terminal charges of the American railroad nullify the profit of the haul itself."

With this evidence at hand it can be clearly seen that the short-haul traffic of the railroad has not been and is not today profitable. Elisha Lee, Vice-president of the Pennsylvania System, stated that, "to the extent to which motor vehicles are likely to take over the short-haul freight traffic, the railroads will probably be immediately benefited financially, because short-haul business is becoming increasingly unremunerative on account of the high proportion of terminal costs which it must sustain."

In the majority of instances you will find, therefore, that motor trucks are handling less than carload shipments within a radius of fifty miles of terminal points on a door-to-door basis. There are over fifteen hundred organized motor express lines in the principal terminal centers doing business on this basis today, in addition to the vast tonnage that is shipped in trucks owned and operated by shippers themselves. As much package freight in all four classes is shipped now by trucks between New York and Philadelphia as by the Pennsylvania Railroad.

The large role that motor trucks are playing in the exchange of freight between the eight railroads that enter Cincinnati is noteworthy. This allocation of transfer freight to the trucks has meant the release for the main line movement of these railroads, 66,362 cars; the elimination of 300,000 switching cuts; the advancement of the freight movement fifty-two hours; and, a saving of thirty per cent in labor through the elimination of the rehandling of tonnage.

This installation consists of electric cranes, motor trucks, and a plurality of interchangeable motor truck bodies. The system of operation requires an empty body for each station movement demand of the railroad on its inbound main station platform. At large stations there are several locations for such body settings, thereby decreasing the trucking distance for freight. As the freight comes from the cars it is trucked to the nearest location containing a body carded for any connection or any sub-station. When loaded, these bodies are sealed and, under telephone order of a joint dispatcher employed by the railroads, mechanically loaded



THE RECEIVING END
Showing the cars being loaded upon trucks for city delivery

onto the trucks and thus routed over the city's streets to the connection. On arrival at the outbound platform of the connecting line the body is mechanically removed and an empty body, previously unloaded, is placed on the truck chassis.

The success of this experiment is certainly going to mean that we will see its duplication, with perhaps some modifications, in every major terminal center in the United States. The full significance of this situation is brought out by the fact that local package freight comprises over 100,000,000 tons annually, or over four per cent of the aggregate tonnage of the railways, although from the nature of the service the revenue received from this traffic and the cost of handling it, bears a much larger ratio to the total earnings and expenses. Approximately one-half of this freight originates at a point on one road and moves to a point on another road. Such freight must be transferred by the originating road to the receiving line at a junction point at its expense, being frequently interchanged several times before the shipment reaches its destination. This interchange is now made either by movement from one freight house to another by trap cars, or by trucking directly across the city.

It is fairly certain that the next great development in transportation in this country will be a national delivery service for picking up traffic at the point of origin and making delivery at the store-door of the consignee, the point of destination. At present the motor truck offers the best solution of this problem. Recently there has been inaugurated the transportation of freight between the New Jersey rail terminals of the Erie Railroad and New York City by means of trucks. The Pennsylvania Railroad is also contemplating the inauguration of a similar type of service for shippers in Baltimore.

The expeditious delivery of less than carload volumes of freight on a store-door delivery basis will be further aided by the extensive development of the container car system of transporting materials, which has been given much attention in the past, and which is now a reality on the New York Central Lines. The containers are designed so that they may readily be removed from the car and loaded upon automobile trucks. They are nine feet long by six feet wide inside, have an inside clear height of seven feet four inches, and a capacity of six thousand pounds. They are substantially built of structural steel, and being entirely of metal will decrease the hazard from losses due to damage by fire. A door is provided in one side of each container, through which the material is loaded and the door then locked and sealed. The container is then placed upon the car where the side of the car which projects above the base of the door gives additional security to the contents, as the door cannot be opened until the container is raised above the top of the side frame. This feature makes the pilfering of goods practically impossible. Besides the facility with which the container and its contents may be handled, this method of transportation is expected to eliminate much of the delay caused by the detailed billing and rechecking of small shipments. It is expected that this container car system will be expanded by the New York Central to completely coördinate the steam railroad, the motor truck and the electric railway.

The motor truck equipment and service furnished by the Cincinnati Motor Terminals Company in the interchange of less than carload freight between the twenty-eight main stations and sub-stations of the steam railroads entering Cincinnati, is also used by the Cincinnati, Lawrenceburg and Aurora Street Railway. With this new type of service, freight received at the Cincinnati down-town station at noon is delivered at the end of the line, thirty miles distant, at three p.m.

Approximately seventy-five per cent of the hauling in the Texas and Oklahoma oil fields is carried on by means of specially designed truck and trailer combinations. There is no question that the motor truck is a very important part of the operator's equipment in the production of petroleum. The impressive sizes to which the truck fleets of some of the largest oil companies in the world have grown during the past few years is a striking confirmation of this statement. With the growing expansion in the utilization of petroleum and the increasing demand for fuel oil, there is certain to come a larger development of motorized service in petroleum fields.

There is every reason to believe also that in the transportation of coal and other mine products from the mouth of mines, there will be from now on a marked tendency to utilize power trucks. Just how extensive this movement will be may perhaps be judged from the fact that the products of approximately 3,200 mines are being carried by either motor trucks or wagons at present.

THE SHIPPING END
Cars being placed upon truck preparatory to loading on railroad flat cars

Good roads, which make possible the extensive utilization of motor trucks and busses in the various channels of commerce, may be rightly said to be the solution of our distribution problem. The total public road mileage of the United States is approximately 2,500,000. The improvement and surfacing of these roads has proceeded during a period of fifteen years at the rate of about six per cent a year. There are now about 300,000 miles surfaced, approximately 165,000 with sand, clay and gravel, and the remainder with macadam, bitumen, concrete, brick, etc. It is evident that the production of surfaced roads is not keeping pace with the increase in wealth, production, and traffic of the country.

(Continued on page 75)

GETTING A JOB WHEN YOU GRADUATE

By WILLIAM E. FLETCHER
President William L. Fletcher Inc., Boston, Mass.

Mr. Senior, have you got your life's job yet? If not, are you directing your energies toward that end according to any system, or are you merely being directed by your intuition and your sense of propriety? You would not consider passing a final examination by your intuition and why go after the greatest thing in life, your life's job, in a less systematic way than you go after a mere final exam. There are a very few principles which may guide you in your search for a job and you cannot afford to be without them. A mere cognizance of them will place you head and shoulders above the man who is seeking his job blindly.

When you start hunting for a position you will probably feel like a marble sliding around and around on a polished surface unable to stop or to control your destiny in the slightest degree. This is a natural feeling, so it will not help any to worry about it. The way to get over this feeling is to appreciate that getting a job is a sales problem and to start work as a salesman to sell your own services.

The most important thing in the world to you is "you" and the most important thing to your employer is "himself". The man who hires you will do so because of what he thinks you can do for him. To get a job you must find out exactly what thoughts your prospect must think before he will hire you and then lead him to think those thoughts. This getting over on the prospect's side of the fence is called getting the "you" attitude.

Do not waste any time and money hunting for the ideal job or for some kind employer who is going to push you ahead in business. The thing to hunt for is an opportunity to render a service. All any good man needs is one foot inside of the door—just one opportunity to demonstrate his value to an employer. Money comes as a reward for service rendered. Looking at a job in this light means to an employer that you have the right mental attitude.

If you will remember this and act upon it, you will avoid one of the greatest misfortunes which can happen to any man starting in business—having his heart broken by an unscrupulous employer. Some companies have a policy of trying to get their work done by young men for very little money. These companies go to the college men upon graduation with beautiful word pictures of the things which come to their faithful employees. As the graduate sees the situation after the officer of one of these companies has talked to him, he has only to take the job offered to find his life work and be happy ever after.

The man who takes one of these jobs finds himself at the end of two or three years in an undesirable position. If he is single and has money in the bank he faces the necessity of quitting his job and starting all over again with some other company. If he is married and has been unable to save any money, he cannot gamble with a new job. His life is ruined. You probably know men in this position. The least said about them, the better. They are the fellows who never show up at their Class reunions or Commencement. The way to avoid being one of them is to disregard whatever an employer tells you about your future with his company. No employer can guarantee your future, and if he could, there is no reason why he should.

William L. Fletcher, as president of William L. Fletcher, Inc., is one of the ablest men in the country to give students advice on how to obtain a position. As head of one of the most unique concerns in the country, he has a very deep insight into a student's troubles in seeking a position. Fletcher handles many high class men of executive and managerial calibre usually drawing from $5,000 to $15,000 a year. When such a man desires a better position, he consults Fletcher and his abilities and past record are thoroughly investigated. Fletcher then recommends him to some corporation and in return for placing such a man, receives commission from the corporation rather than from the man placed.

Mr. Fletcher is also the author of "How to get the Job You Want," printed by Houghton Mifflin Co. It is an especially valuable book to college graduates entering the business world.—*Editor.*

In looking for a position you should proceed in a constantly widening circle. First approach your nearest neighbor. Tell him exactly what you want so far as you know. Do not ask him if he knows of any such job but if he will help you find one. Get him to thinking about your problems, and working for you. Ask all your friends to help you. Get them at work on your problem.

The following sources of prospects should be investigated: friends and business acquaintances; help wanted advertisements in newspapers and trade papers; news items, magazine articles and general advertisements; directories and mailing lists; schools, colleges, clubs and business associations; new corporations and companies being organized; situations wanted advertisements in newspapers and trade papers; employment agencies.

If you find it hard to think of prospects among your friends and acquaintances, go over old scrap books, address books, correspondence files, family albums—everything you have. You will find many prospects in this way. Of the sources of prospects which I have given, three, outside of friends and acquaintances, are particularly worth while. These are "Help Wanted" advertisements in newspapers and trade papers, "Situations Wanted" advertisements in the same papers, and direct mail campaign.

If you are an officer in your class or a member of the football team or a good debater or an active fraternity man, this means that in some ways at least, you are above the average man. In trying to get a position you should always use as a sales argument everything you did in college which tends to prove that you have ability as a leader of men. If you have managed an athletic team or a musical club or a dramatic club successfully, this is always a good point to bring out.

If, in analyzing yourself, you find that you have not excelled in any way, use this fact as an argument. Generally speaking, business men are not looking for "boy wonders"; they do not want men to revolutionize their business. What they desire are men of average intelligence, with open alert minds, who have some appreciation of the importance of discipline and are willing to work and study hard to get ahead. The man who has not excelled in college should tell prospective employers that he possesses only average ability, but that he can and will accept suggestions and will work hard to get ahead. In other words, turn every objection into an argument when you can possibly do so.

Probably more men secure positions by answering "Help Wanted" advertisements in newspapers and trade journals than in any other one way. It is important, therefore, that you know how to answer an advertisement. The first point to keep in mind in answering an advertisement is that you are not applying for something. A letter of application is a sales letter. You are trying to sell your own services. In your answer to an advertisement you should try to do only one thing—get an interview with the employer. To do this the em-

ployer must say to himself when he has read your letter, "This is the kind of man I want." You must lead him to think this thought.

You create this thought in his mind by doing five things; giving in your letter all the information asked for in the advertisement; making your letter clear, concise, correct, and courteous; using strong first and last paragraphs; keeping the employer's interests in mind all the time you are writing to him; giving definite information (facts, not generalities) about what you have done, can do, and want to do. The first and last paragraphs of your letter are particularly important. Do not begin your letter with a statement to the effect that you have seen his advertisement and are convinced that you are exactly the man he needs. The employer knows this without your telling him. If this were not true you would not answer his advertisement. Do not "tune up in the presence of the audience." Start right in to tell him why you are the man he wants. If you find it hard to do this, write your letter as you naturally would write it—and then throw the first paragraph away. Always end the last sentence with a period. A simple statement such as "You can reach me by telephoning Main 4000" is a good ending. Do not try to force the employer into taking action.

In writing a letter you should never use any expressions which you would not use if you were talking to your prospect. This means that you must eliminate all such hackneyed expressions as "Beg to remain." Do not use the words "beg," "state," or any of those other expressions which are so common in business letters but mean so little. The stationery which you use is very important. The quality of paper and envelope should be as good as you can afford. Do not under any circumstances write a letter applying for a position on ladies' note paper. Use a sheet eight and one-half by eleven or gentlemen's note paper, which should measure not less than six and one-half by nine inches. The envelopes for this size are four and three-quarters by six and three-quarters. In reading answers to advertisements nine employers out of ten will select and read first the letters which come in the best looking envelopes. Unless an employer states in his advertisement that he desires all answers written with a pen, your letter should be typewritten. See that the type is clean and that the letter has a neat appearance.

If you are going to run a "Situation Wanted" advertisement to secure a position, you should place it in the paper or papers which are read by the people you wish to reach. In a large city, the papers which carry the largest amount of advertising are the best mediums. A fifteen or twenty line advertisement is much more likely to pull a good job than a small advertisement.

Many employers follow "Situations Wanted" advertisements in newspapers very closely. These men reason that the men who advertise for the positions they desire have more initiative than the men who try to secure positions simply by answering "Help Wanted" advertisements. "Situation Wanted" advertisements in the trade papers are very well worth while, because these papers are read by intelligent, progressive employers. If the paper in which you are advertising permits display head lines in its classified columns, you will do well to use one. If you start advertising for a position, do not expect results from your first advertisement. Run your advertisement three times during one week and check up the results. If you think it advisable, change your copy and run the new advertisement three times the next week. Always run your advertisements on the days when your medium has its largest circulation. Advertisements run on holidays, however, are probably not extensively read.

Under normal business conditions, a direct mail (circular letter) campaign to get the job you want is almost certain to produce satisfactory results. All you have to do to get a job is to keep at it until you win. For the man who has a weak personality or who finds it hard to talk to strangers or has some other weakness, direct mail campaigns are worth very careful consideration. Through letters, you can anticipate and overcome objections. If you cannot write a good letter, you can always get a trained advertising man to help you.

The principles which you should observe in running a direct mail campaign are the same as those you follow in answering an advertisement. One good way to run a campaign is to prepare a letter carefully and then send out ten copies. Enclose stamped, self-addressed envelopes for replies. When your answers are received, you will probably be able to determine the value of your letter. If the first ten letters do not pull satisfactory results, have an advertising man check up your letter to see if it is a good one. Do not mail letters so that they will be received by prospects on Saturday or Monday. Letters received by business men on these days do not receive the consideration given to letters received in the middle of the week. The days just before and after holidays are also bad days to have your letter reach prospects. Telegrams and night letters can sometimes be used instead of letters. They always get attention.

THE GROWTH OF HIGHWAY TRANSPORTATION

(Continued from page 73)

An interesting test was recently made in the State of Michigan, which proved conclusively that it took twice the amount of gasoline to take a loaded truck over dirt roads as it did over improved roads. It was further discovered that the two-ton truck under observation traveled at an average speed of 4.6 miles an hour on the dirt roads in contrast to the 16.4 miles an hour on the improved stretches. In the light of the results of this test it is easier to appreciate to the full the significance of the statement that our farmers are losing annually $300,000,000 on their market crops on account of poor roads.

It is estimated that during the course of the present year the United States Government, the states, the counties, and the municipalities combined, will spend fully one billion dollars for highway purposes. In anticipation of a corresponding growth in highway production in the next ten years, plans are being made now to train six hundred university highway engineers for service in the county and municipal and other highways organizations.

The work involved will not be routine as there are many principles to be worked out.

Thomas H. MacDonald, Chief of the Bureau of Public Roads, made the assertion recently that "engineers have been prompt to develop methods of improvement which are salvaging practically the full value that was originally invested in the highways.

"For example some of the older macadam roads in New York State, lightly built, which are now heavy traffic lines, have been widened by concrete roadways on either side, preserving a strip of macadam, say six feet wide, in the center, thus giving a twenty-four foot usable surface by the addition of 18 feet of new construction. The remainder of the macadam width is sacrificed and the material spread to form a better base under the new construction. This is only one example of so many successful operations of like construction that it may be taken as a principle that if roads are well maintained when traffic becomes so heavy that reconstruction is necessary, the major part of the investment can be preserved and be built into the new highway as an integral part."

ELECTROCHEMISTRY IN THE WOOD PULP INDUSTRY

By ARTHUR B. LARCHAR
Penobscot Chemical Fibre Company, Great Works, Maine

The fundamental ideas concerning chemical changes induced by the electric current, which were first conceived by Davy and Faraday, found commercial application when the development of electrical generating machinery placed at the chemist's disposal a sure source of large, unvarying, continuous currents.

The extraction and refining of metals by electrochemical processes, the arts of electroplating and electrotyping, as well as the cheap and convenient preparation of several gases and compounds by similar methods have become of large industrial significance.

Two of the chemicals which are being produced by electrolytic methods are of importance in the manufacture of cellulose, from wood. These are sodium hydroxide and calcium hypochlorite, usually designated as caustic soda and bleach.

Wood pulp whether separated from the non-fibrous elements of wood by means of acid or of alkaline treatment retains some brownish, ligneous residue which cannot be removed by the washing which the fibre undergoes after treatment in the digesters.

When the pulp is made by the alkaline, or soda process, the digestion which effects the separation of the fibre is carried out in the presence of a solution of caustic soda, so that both of the chemical agents mentioned, i.e. caustic soda and calcium hypochlorite are required for the manufacture of soda pulp from wood.

Prior to the advent of the electrolytic process for the decomposition of brine, caustic soda solution for use in the soda mill digesters was prepared by boiling soda ash with lime. This practice is still continued as a step in the reclaiming of the alkali which has been used in the process of wood digestion. But whereas the loss of soda incident to the mill processes was formerly made up by the causticizing of fresh soda ash, several mills now use caustic soda produced electrolytically on the premises for this purpose, thus relieving their causticizing equipment materially.

Moreover, large tonnages of bleaching powder and caustic soda are made by electrolysis in plants independent of the pulp mills, so that the electrolytic method is a competitor of the ammonia soda process in the production of caustic, and has furthermore prevented the extension, if not indeed imperilled the existence, of the Le Blanc works.

A well designed soda pulp mill operating on poplar, or similar wood, requires one hundred and fifty pounds of caustic soda per ton of product for replacing the alkali lost in the digesting, washing, evaporating, incinerating and causticizing system. The same mill requires the equivalent of two hundred pounds of bleaching powder to bring each ton of product to a standard color.

Inasmuch as an electrolytic cell produces chlorine and caustic soda in the proportion of one pound of caustic soda to the equivalent of slightly over two and one half pounds of standard bleaching powder, it is evident that an electrolytic plant large enough to furnish the caustic soda needed for a soda pulp mill would produce nearly twice as much bleaching liquid as could be used in whitening the pulp.

The electrolytic units or cells, now commercially employed in decomposing brine for the purpose of producing bleaching compound and caustic soda from sodium chloride have been the subject of much ingenious experimentation. A great deal of pioneer work in the development of suitable apparatus has been done in the State of Maine, which, from its hydraulic possibilities and its leadership in the art of pulp making, is an excellent field.

One of the earliest experiments was with the process of hermite at the plant of the Forest Paper Company at Yarmouth. This process employed magnesium chloride as an electrolyte, and of course produced no soda. Platinum anodes and zinc cathodes were used without a diaphragm, and magnesium hypochlorite was the result of the electrolytic action. It was hoped that the magnesium chloride could be recovered from the bleaching liquor after its action upon the pulp was completed, but this was found impractical.

Le Sueur at Rumford in 1893 made the first bleaching powder produced commercially in the United States and his early work was doubtless the stimulus and inspiration to many later workers. Le Sueur employed a diaphragm in his cells. His anodes were fragments of carbon from gas retorts.

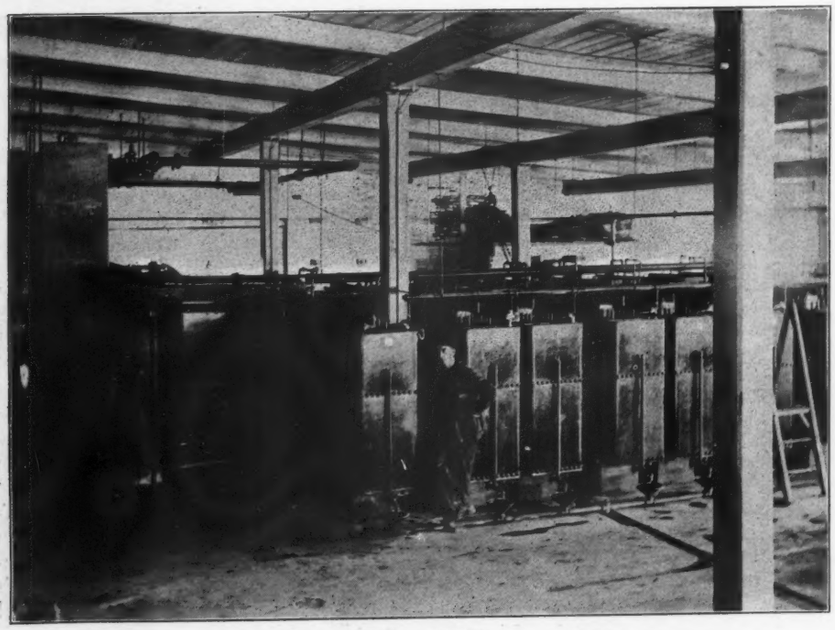
Professor Carmichael of Bowdoin College designed an electrolytic cell in which networks of platinum wires served as anodes. This type was in large scale operation at the Cumberland Mills plant of the S. D. Warren Paper Company for several years.

The Whiting type, employing a cathode of mercury, is represented by a large installation at the mills of the Oxford Paper Company in Rumford.

A plant having capacity for making bleach liquor for a daily tonnage of soda and sulphite pulp combined of one hundred and forty tons is operating at Great Works, while a somewhat smaller plant is producing bleach liquor for sulphite at South Brewer.

Several soda pulp mills in other sections of the country are operating electrolytic cells, usually of the diaphragm

(*Continued on page 90*)



A CORNER OF AN ELECTROLYTIC CELL ROOM
The cells here illustrated are 3000 ampere units. The simple external appearance is worthy of note

PROFESSOR HEINRICH OSCAR HOFMAN

By PROF. CARLE REED HAYWARD, '04
Associate Professor of Metallurgy, Massachusetts Institute of Technology

At the close of the present school year the Institute faculty loses Professor H. O. Hofman, who becomes seventy years of age on August 13 and thus must be retired under the rules of the Carnegie Foundation. At that time he will have completed thirty-three years on the Technology faculty.

Professor Hofman was born in Heidelberg, Germany, in 1852, where his father, Karl Hofman, was on the faculty of the university. His mother was of English parentage. He became interested in the sciences and during his course at Heidelberg University came under the influence of such men as Kirchoff and Bunsen. After leaving the university he studied at the Clausthal Mining Academy where he graduated with honors, receiving the degree of Mining Engineer and Metallurgical Engineer in 1877.

After four years of practical work Professor Hofman came to the United States and in 1881 entered the employ of the Mine La Motte Company as metallurgist. Later he served in a similar capacity at the Argentine Works, Kansas; the Delaware Lead Works, Philadelphia; Grand View Mining and Smelting Company, Rico, Colorado; and the Carmen Mining Company, Villaldama, Mexico.

Professor Hofman's first connection with Technology was in 1885 when Professor Richards, Head of the Department of Mining and Metallurgy, asked him to give a course of lectures on lead smelting. He later substituted for Professor Richards in teaching both mining and metallurgy, and then was employed as his private assistant for two years, leaving in 1887 to become Professor of Metallurgy and Assaying at the South Dakota School of Mines. In 1889 he became Assistant Professor of Mining Engineering and Metallurgy at Technology. The same year, also, he received the degree of Ph.D. from Ohio University. He served successively as Associate Professor and Professor of Metallurgy, and at the retirement of Professor Richards in 1915 was placed at the head of the Department of Mining and Metallurgy, and remained in charge until 1920 when the department was consolidated with the Department of Geology. During this period the laboratories in the present building were planned and equipped. The latest honor he has received is election as an Honorary Member of the American Institute of Mining and Metallurgical Engineers. This distinction, which is shared by only sixteen others, was conferred on him in June, last year.

In 1883 Professor Hofman was married to Josephine Loughead of Philadelphia, who died some years later. In 1902 he was married to Fanny E. Howell of Boston. They have two children, Erik, born in 1904, and Nancy, born in 1908.

HEINRICH OSCAR HOFMAN

It has been easy to write the facts given in the preceding lines, but it is more difficult to describe adequately Hofman, the student, the teacher, and the man. Technical literature has been greatly enriched by his numerous publications, giving the results of research, discussions of metallurgical papers, and annual reviews of the metallurgy of lead. His first book, "Metallurgy of Lead," published in 1892, at once became a standard work. It ran through several editions and was completely rewritten in 1918. This book, together with his other writings, established him as one of the foremost authorities on lead in the country. His "General Metallurgy," published in 1913, "Metallurgy of Copper," published in 1914, and "Metallurgy of Zinc and Cadmium," published in 1921, are standard treatises which will be valuable for years to come and have given their author a permanent position among the world's greatest metallurgists.

The painstaking care with which Professor Hofman works on his books is a marvel to all his associates. For years he has looked over all the periodicals coming to the department library, and had important articles catalogued. Every statement in his writings is backed by references and this complete bibliography is an important addition to the carefully selected material used in the text. After getting the material together it was his custom to visit the important smelting plants to familiarize himself with the latest practical developments and bring his book up to date. A wide circle of friends among operating metallurgists kept him familiar with plant practice, and this feature is abundantly reflected in his books.

Professor Hofman's mind is a wonderful storehouse of metallurgical information, and he has always had a remarkable faculty of remembering references to published data. Times without number the writer has been given the answer to a question and with it a reference on the subject either in a book or a periodical.

As a teacher Professor Hofman always had the respect of his students, encouraged them to ask questions, and was patient in answering them. His lectures abounded in concise statements of facts and he seldom departed from fundamental principles. Unfortunately few of the students availed themselves of the opportunity to become really acquainted with him. It was to those whose theses were directed by him that Hofman the man became more completely revealed. They learned more of his kindly and sympathetic nature and marveled that one who was so thoroughly a master of his subject could be so modest and unassuming.

At the outbreak of the war in 1914, Professor Hofman at once espoused the cause of the allies, and was in its early stages more outspoken against Prussian militarism than most of his American colleagues.

Although retiring from active teaching Professor Hofman plans to retain a desk at Technology and will devote his time to a new treatise, "The Metallurgy of the Minor Metals."

VOLATILITY OF MOTOR FUELS

The method of determining the curves used with this article which appeared in the May issue was worked out in the Research Laboratory of Applied Chemistry and is described in the Journal of the Society of Automotive Engineers, Vol. IX, November, 1921, and in the Journal of Industrial and Engineering Chemistry, Vol. 13, October, 1921.

Decreased Use of Explosives. The quantity of explosives used in the United States during the calendar year 1921 was lower by more than thirty per cent than the amount consumed in 1920, according to the Bureau of Mines. Reports received by the bureau show that the total sales amounted to 372,107,503 pounds, as compared with 537,954,750 pounds the year before. Of the total amount sold 160,021,250 pounds (43.0 per cent) was black blasting powder, 170,952,402 pounds (45.9 per cent) "high" explosives other than permissible explosives, and 41,133,851 pounds (11.1 per cent) permissible explosives. As compared with the preceding year these figures indicate a reduction of 37.2 per cent in sales of black powder, 25.4 per cent in "high" explosives, and 23.8 per cent in permissibles. Permissible explosives are those which, because of having passed certain tests prescribed by the Bureau of Mines, are considered reasonably safe for use in gaseous and dusty coal mines.

Railroad and other construction work was the only branch of industry using a larger quantity of any kind of explosives than in 1920. In other industries there was a decrease of about fifty per cent.

During the first quarter of the current year 566 men have been killed at coal mines as compared with 494 during the corresponding quarter last year, an increase of 72 fatalities, or more than 14 per cent. The output of coal for the same periods was 150,923,000 tons and 124,030,000 tons respectively, an increase in 1922 of about 22 per cent. The increased production has resulted in a decline in the fatality rate per million tons mined from 3.98 in 1921 to 3.75 in 1922.

New White Pigment. An English concern has recently put on the market a white pigment, white oxide of antimony, under the trade name *Timonox*. The method of manufacture is said to be entirely new, but details of it are lacking. It is exceedingly fast, and opaque, has high covering power, and so far has produced no deleterious effect on the health of the workmen engaged in its manufacture. It has been shown to be of especial value in the manufacture of enamels.

Professor R. E. Wilson, '16, has been chosen for a member of a special committee of the Petroleum Section of the American Chemical Society, for promotion of research on petroleum in coöperation with Dr. Van H. Manning, director of research for the American Petroleum Institute. The other members of the committee are: W. F. Faragher, chairman, Mellon Institute, Pittsburgh, Pa.; R. P. Anderson, United Natural Gas Company, Oil City, Pa.; N. A. C. Smith, Bureau of Mines, Pittsburgh, Pa.; C. E. Waters, Bureau of Standards, Washington, D. C.; R. R. Matthews, Roxana Petroleum Company, Wood River, Ill.; E. W. Dean, Standard Oil Company, 26 Broadway, New York.

Activities of Bureau of Mines. A method for distilling clay similar to the manner in which coal is distilled has been devised by engineers of the ceramic experiment station of the Burau of Mines. The object of this method is to collect the products of distillation and determine the gases given off.

The dust studies made to date in metal mines of the United States by the United States Bureau of Mines indicate definitely that wet drills as used in drilling of all classes of holes aid decidedly in reducing dustiness of air in drilling places. However, it has been found that wet drills, whether of the Leyner type or stopers, if not operating satisfactorily or if out of repair, may throw into the air of working places a mist or fog, laden with minute mineral particles which, when breathed, has the same effect as dry dust and is fully as dangerous. In addition to danger when wet drills are not efficiently used, if water or compressed air and water forced through the drill is under excessive pressure, say over one hundred pounds per square inch, there may be danger of escape of mist or fog laden with mineral particles, hence these pressures should be held below one hundred pounds per square inch, which, in general, is the practice in the United States. Wet drills must be kept in repair and must be operated with intelligence; as far as proved by the sampling of the United States Bureau of Mines, the wet drills still give conditions much more healthful than do dry drills.

Train Radio Service was inaugurated recently by the Lackawanna Railroad. A public test of radio train equipment devised by D. W. Richardson, a Princeton student, assisted by G. D. Murray, Jr., and E. G. Sisson, Jr., both graduates of Princeton last year was made on a special train running from Ithaca to New York. A series of conversations with amateur radio stations along the line was made when the speed of the train was sixty miles per hour. While the train was in mountainous country a concert was given by the General Electric Company broadcasting station at Schenectady in order to test the receiving apparatus in tunnels and around mountain bends. Concerts were also received from Pittsburgh. The train transmitting set has a range of only twenty miles while the receiving outfit has a regenerative set, a specially built amplifier for train work, detector and two steps of audio-frequency amplification with power amplifier used in conjunction. The antennæ are six wires on cages four and one-half inches in diameter erected on buffet and dining cars.

To Harness Hawaiian Volcano? Plans are being made to start experimental borings in the bed of the active volcano of Kilaueal to determine the possibility of obtaining power from this source. Dr. T. A. Jagger said that at least fifty borings would be made to provide a thermal map of the hot belt. Eight thousand dollars is being raised to defray the expenses of the investigation. If the results are satisfactory, a power station will be erected.

A New Dye, recently invented by a Manchester firm, enables materials to be dyed two shades with only one immersion. The discovery and perfection of coloring which has no attraction whatever for cotton, has made it possible to accurately place different shades of color on a white cloth. The new substance, called *Ionamines*, affects only silks or artificial silks, and by using this together with known dyes, such as chlorazel blue, which have affinity for cotton only and using cloth which contains part cotton and part silk or artificial silk it is possible to secure almost any design conceivable.

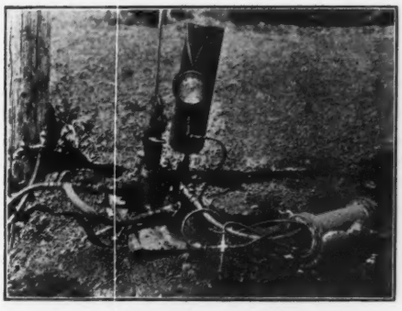
Speaking Movies that work are next in order, according to Lee De Forest, who recently returned from Germany. The device he describes is entirely different from the processes that have been tried previously. The voice is registered on the movie film by a tiny ray of light as in photography. A very narrow strip of the regular film is given over to the registry of the voice. Light passing through the negative in various degrees of intensity is changed from light waves to sound waves by a delicate and ingenious mechanism. They are then passed into an intensifier and thus to the audience. The voice and action of the picture are said to be perfectly coördinated. The principles involved are said to be not unlike those employed in the transmission of photographs over telegraph lines.

New Cable. Before the end of 1923 that area of the Atlantic between the United States and the Azores will be spanned by a submarine cable capable of carrying ten times as many messages as any line now in existence. Plans have been completed to extend the new communication link later from the Azores to Emden, Germany. In its final state the proposed cable will be 4,400 miles long.

IXM, the station of the M.I.T. Radio Society is reported to hold a record for long distance transmission on short waves. Signals from M.I.T. have been heard clearly in Scotland, Panama, and very recently, in Hawaii. C. J. Dow, of Wailuku, Maur, of the Hawaiian Islands reported a short time ago that he heard IXM distinctly with a one-step amplifier. The Radio Society was then using two fifty-watt transmitting tubes with one thousand volts rectified alternating current. The radiation current was about six amperes.

Gasolineless Motor. Experiments conducted by the National Advisory Committee for Aeronautics under the direction of Dr. Joseph S. Ames, have developed an airplane motor which uses heavy fuel oil instead of gasoline. No special processing of the oil is required. The motor itself is a modified Liberty, with the length of the pistons increased to provide greater compression. There are no valves. The oil, very thick and gummy, is forced through a jet by compression pumps and enters the cylinder under high pressure. The incentive which pushed the development for airplanes was the high inflammability of aviation gasoline which has made hydrogen filled dirigibles, in particular, so hazardous. The great problem of making the motor light enough for an airplane has been overcome in a large measure. There is no reason why a similar scheme cannot be used for automobile engines.

Irrigation Pipe Testing. Field tests on concrete irrigation pipe, which it was hoped would form the basis for standardization, were begun by the Bureau of Public Roads of the United States Department of Agriculture through its agricultural engineering division, in 1917. Many of the problems the tests were to solve had not been attacked in a serious way before, and the devising of testing apparatus was necessary. Some of the apparatus was as novel as it was successful. The tensile strength tester, for example, did away with cumbersome bulkheads,



PIPE TESTING APPARATUS
Designed by Division of Agricultural Engineering to test concrete irrigation pipe

joints, and connecting rods formerly used, and permitted the testing of single lengths of pipe. The tester is of aluminum, cylindrical, and about a foot long. Metal grooves, U-shaped, encircle the ends of the cylinder, and into these, rubber tubing is inserted. For a test, the cylinder is inserted in a joint of pipe, water under pressure is turned into the tubes to make water-tight connections, and the pressure is increased until the pipe is broken. Testers to determine other qualities of concrete pipe, both for laboratory and field demonstration were also devised by the Department.

The tests sought to determine the breaking pressure of, and seepage through, stock pipe in various yards in California, which were considered in connection with the facts regarding the materials, mix, and curing. Later experiments determined such matters as the absorptive capacity of concrete, specific gravity, the grades of materials, qualities of cement and sand, crushing strength of concrete, and the bearing pressures of concrete pipe when subjected to heavy fills or loads.

Treating Hay Electrically by an ingenious invention said to be of Swiss origin triples its nutritive value as cattle fodder. The grass is processed without drying. It is first shredded and blown into a silo by a fan. An alternating current of 220 volts potential is then passed through the hay from a plate at the top of the silo to a plate in the floor.

BOOK REVIEWS

Radiophone Receiving. By nine specialists, edited by E. Hausmann. D. Van Nostrand Co., New York. Illustrated, 4½ by 7¼. 179 pp. $1.50: 1922.

This is a practical book for everybody interested in radio reception, written without the use of complicated mathematical formulæ so that it is intelligible and interesting to all. The method of treatment is more or less elementary. No perplexing theory is discussed, but instead a complete outline is given of the important pieces of apparatus needed for the reception of wireless messages. Many simple diagrams and illustrations are used to convey the writer's meaning. Wherever possible, mechanical analogies are used to explain the actual internal working of the receiving and transmitting stations.

The first chapter begins by explaining sound: how it is produced, and how it is transmitted. The simple telephone is taken up and sound and electric waves are compared. The book proceeds to explain the different pieces of apparatus in common use. Condensers, tuners, resistances, telephone receivers, etc. Crystal rectifiers are explained, and finally vacuum tubes are taken up and discussed in their various uses and applications to receiving sets as both detectors and amplifiers. The last chapter considers the use of the vacuum tube in wireless transmission.

Taken as a whole the book should be of particular interest and value to the radio amateur who has come into the game anxious to get results, and who is not interested particularly in the higher theory or mathematics involved.

Applied Calculus. By F. F. P. Bisacre. D. Van Nostrand Co., New York. Illustrated, 5 by 7½. 416 pp. $3.75: 1921.

"This book is intended to provide an introductory course in the Calculus for the use of students—whose knowledge of mathematics is slight."

The introduction and the first chapter review the basic principles of algebra and analytic geometry and take up the fundamental principles of calculus such as the notion of limits. The next twelve chapters consider the ordinary methods of calculus, differentiation, integration, and applications thereof, including many practical problems, besides the usual maxima and minima, curvature of plane curves, etc. In chapters fourteen, fifteen and sixteen respectively are found discussions of many interesting problems in electricity, chemistry and thermodynamics. The book is completed by the addition of many miscellaneous exercises, biographical notes, and integral and logarithmic tables.

PHOTO-ELASTICITY AND ITS APPLICATION TO ENGINEERING PROBLEMS

By PAUL HEYMANS, D. Eng. Sc., University of Ghent (Belgium)
Research Associate, Research Laboratory of Industrial Physics, Massachusetts Institute of Technology

Copyright, 1922, by Division of Industrial Co-operation and Research, Massachusetts Institute of Technology. All rights reserved including translation into foreign languages, including the Scandinavian.)

One of the important and often difficult problems with which an engineer has to deal is the determination of the shape and the dimensions which

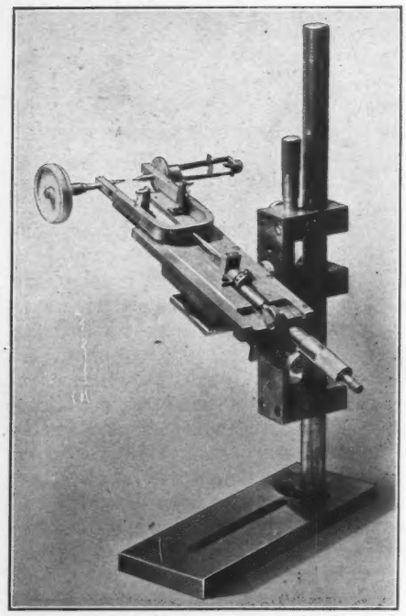


FIG. 1
DR. COKER'S LATERAL EXTENSOMETER

he must give to the different parts of a proposed construction. Several factors have to be considered, but the dominant ones are safety and economy.

As we know, materials yield at points where the stress exceeds the elastic limit. If we were able to make a complete determination of what the stress would be at each point of the structure, it would be easy to give to all parts adequate dimensions; a minimum of material would be wasted and safety would be secured.

Notwithstanding the progress made in mathematical treatment of elastic problems, the determination of the stress distribution remains in most cases an unsolved problem. Where theoretical solutions exist, even in the relatively simple cases, they usually lead to lengthy and intricate calculations, and it cannot be expected that even a well-trained engineer will use them in practice.

The uncertainty of knowledge of the stress distributions, on which the determination of the dimensions of the different parts of a construction has to be based, requires the use of an excessive factor of safety. All the material added above that strictly necessary means waste. Accidents frequently occur which show that, notwithstanding all precautions, safety in design has not been secured.

The object of the mathematical theory of elasticity is the analytical determination of this stress distribution. Photo-Elasticity, consisting of recently developed methods of optical investigation of the stress distribution, leads to an experimental solution for all two-dimensional elastic problems, provided the material used is isotropic and obeys Hooke's law of linear proportionality between stress and strain, *i.e.* within the elastic limit of the material.

As we know, the number of cases, for which a complete mathematical solution for the determination of stress

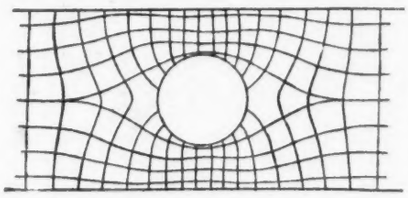
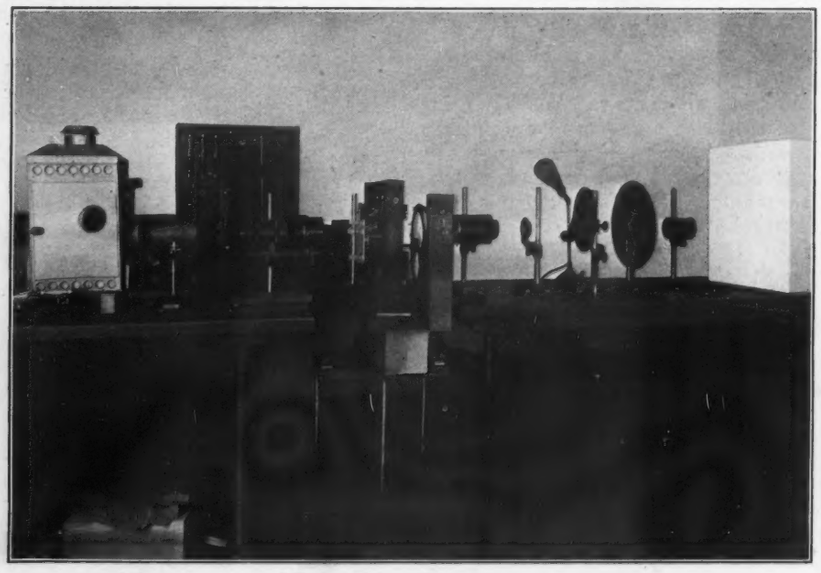


FIG. 4
LINES OF PRINCIPAL STRESS

distribution exists, is limited, and the calculations worked out in practice for the computation of stability are, in general, an adaptation of the ideal or incomplete theoretical solutions to the needs of engineering practice. The simplifying assumptions, which have to be made, may be seen, by closer analysis and especially by photo-elastic investigation, to be quite often of doubtful accuracy, and may lead, especially in new or unusual problems, to dangerous approximations.

Polarizer Model under examination Comparison member Analyzer White screen



GENERAL VIEW OF APPARATUS USED IN THE OPTICAL STRESS ANALYSIS

I. GENERAL PRINCIPLES OF ELASTICITY AND PHOTO-ELASTICITY

The state of stress at any point of a body is determined when the traction across every plane through the point is known. There exist at any point three orthogonal planes, across which the traction is purely normal and which are called the planes of principal stress. The normal tractions across those planes are called the principal stresses. So *the state of stress at any point is completely determined by the direction and the magnitude of the principal stresses* at the point under examination. These are therefore the elements which we determine in a stress analysis.

Most of the isotropic transparent bodies, such as glass, or still better such as xylonite (1) are optically inactive in their normal state, but show double refraction when put under stress. *The photo-elastic methods of stress investigation*, whose develop-

(1) Xylonite is camphorated nitro-cellulose, of the same kind as celluloid.

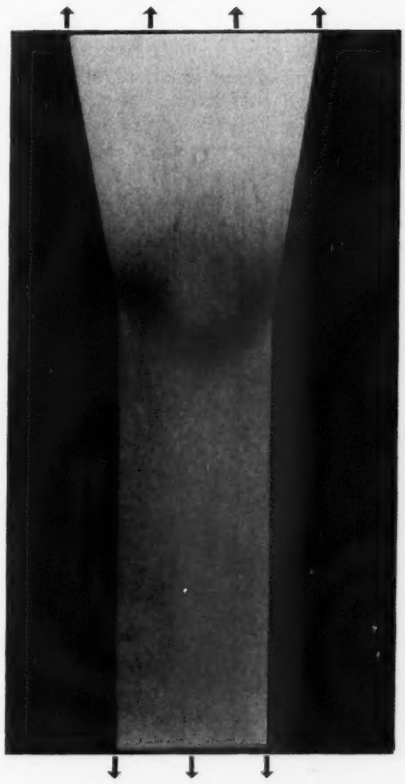


FIG. 2
BEAM OF RECTANGULAR CROSS SECTION UNDER LONGITUDINAL PULL

ment, as described in this article, has been mostly carried out under the direction of Prof. E. G. Coker (University College, University of London), *are based upon these temporary birefracting properties shown by transparent bodies when stressed.*

If plane polarized light is first passed through a stressed specimen of xylonite and afterwards through a second Nicol prism, whose principal section is parallel to the plane of polarization of the original beam of light, only the points where the principal stresses are respectively parallel and perpendicular to the principal sections of the crossed Nicols remain dark. This property enables us to determine *the directions of the principal stresses* at any given point.

If now we pass through the specimen circularly polarized light, by interference of the two component rays (which in the double-refracting specimen have suffered a relative retardation, depending at each point on the magnitude of the two principal stresses), a colored image is obtained.

By a comparison method, based upon the interposition in a suitable direction of a comparison member of constant cross section, put under uniform tension in an appropriate frame, we read on the dynamometer of the frame the value of *the difference of the principal stresses* at any given point.

Now, in the two dimensional elastic problems, the transverse deformation, *i.e.*, the deformation along a normal to the plane of the two principal stresses, is proportional to *the sum of those two stresses.* By means of Dr. Coker's lateral extensometer (Fig. 1) we measure this transverse deformation.

From the values of the differences and the sums of the principal stresses, we compute the separate values of each of them, so determining completely the elastic state.

The question naturally occurring to an engineer is whether the results, obtained on a transparent body such as xylonite, are of any value for engineering materials. It is shown by the general discussion of the equations of elastic equilibrium that *in the case either of plane strain or of plane stress,* in an isotropic body, obeying Hooke's law of linear proportionality between strain and stress, *the stress distribution is independent* of the moduli of elasticity and consequently *of the nature of the body.* So, the stress distribution experimentally determined on xylonite is the same in any other isotropic substance obeying Hooke's law, among others, in steel (2). Moreover these conclusions derived from the general theory of elasticity have been checked by experimental work.

II. PHOTO-ELASTIC STRESS ANALYSIS APPLIED TO:

A. *Some simple cases.*

Let us first consider the application of photo-elasticity to a few simple problems in order to make clear the different processes.

(2) Except, however, if the body is multiply-connected and the resultant applied forces do not vanish separately over each boundary. In this particular case the correction coefficients for passing from one isotropic substance to another, having different values for the elastic constants, may be experimentally determined. ("On Stresses in Multiply-Connected Plates," by L. N. G. Filon. British Assoc. Report, 1921.)

1. If we pull uniformly a xylonite *beam of rectangular cross section,* which is optically inactive in its normal state, the uniform color which will appear, as

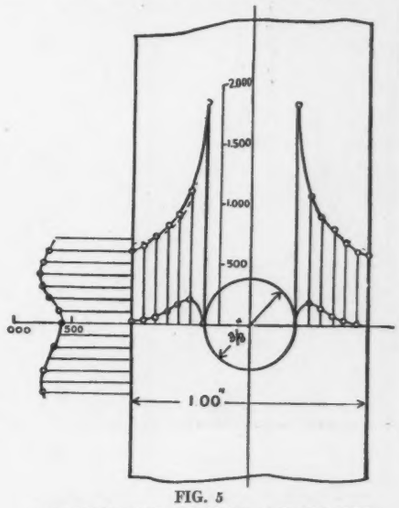


FIG. 5
THE PRINCIPAL STRESSES ACROSS THE MINIMUM CROSS SECTION AND ALONG THE OUTSIDE EDGE

it is put under stress, shows us (Fig. 2) where we have uniformly distributed tension.

If, in the central part of this same beam, previously under uniform tension, *a circular hole* is drilled, free from initial machining stresses, the image obtained (Fig. 3) shows that this internal discontinuity causes a very different distribution of stress. For one not familiar with these phenomena, the interpretation of such images may be somewhat difficult. It may be made easier by pointing out that the isochromatic lines or zones (lines or zones of same color) correspond to equal values of difference of principal

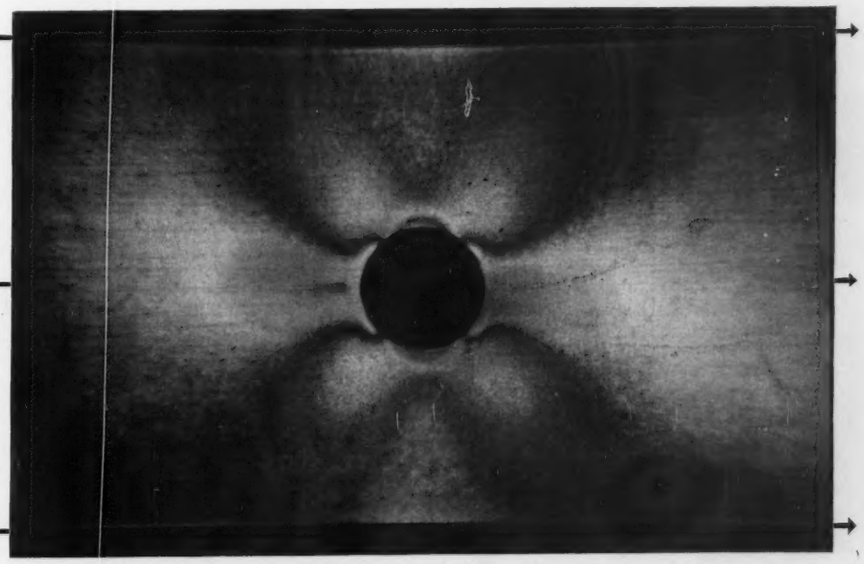


FIG. 3
A CIRCULAR HOLE IN A BEAM OF RECTANGULAR CROSS SECTION UNDER LONGITUDINAL PULL

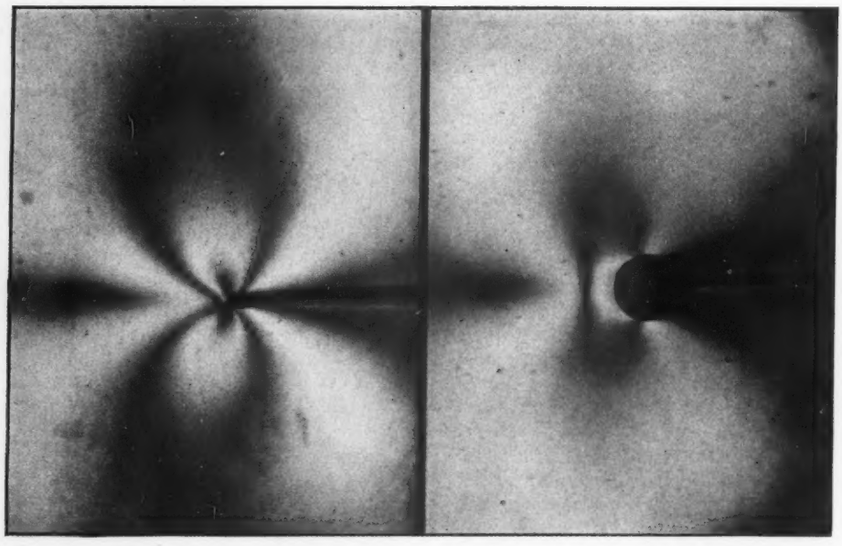


FIG. 8
Stresses at the Ends of a Crack

FIG. 9
A Circular Hole Drilled at the Ends of the Crack

A CRACK IN A BEAM OF RECTANGULAR CROSS SECTION UNDER LONGITUDINAL PULL

stresses. The image shows, among other things, that the stress is not uniform across the minimum cross section and that therefore the engineer makes an approximation, already in this very simple case, when he bases the calculation of the cross section on the mean stress through the active section.

The analysis of the stress distribution in a beam of rectangular section, in which a circular hole has been drilled (3), is shown on Figs. 4, 5 and 6.

Fig. 4 shows what are called the lines of principal stress. The tangent and the normal to those lines define at each of their points the directions of the principal stresses.

Fig. 5 shows the values of the principal stresses across the minimum cross section, and the polar diagram of Fig. 6 shows, with the boundary of the hole as origin for the values of the stresses, the value of the tangential stress at the boundary of the circular discontinuity.

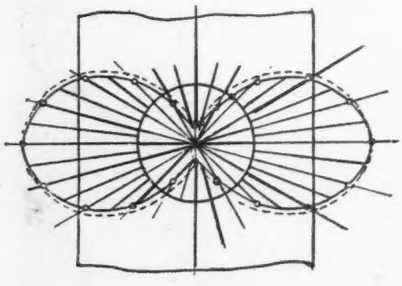


FIG. 6
THE TANGENTIAL STRESS ALONG THE BOUNDARY OF THE CIRCULAR HOLE

(3) Diagrams 4, 5 and 6 are taken from: "The effects of holes and semi-circular notches on the distribution of stress in tension members," by E. G. Coker (Proc. Physical Soc. London, vol. XXV, Part II).

What is most striking here is:

For the diagram of Fig. 5, that the maximum value of the stress, which occurs at the inside edge, is equal to about 1.8 times the mean stress. That ratio is the approximation made by the engineer when he calculates the section assuming that the stress is uniformly distributed.

For the diagram of Fig. 6, that the stress at the inside points of the hole where the longitudinal axis of the member cuts the boundary of the hole, the tangential stress is a compression.

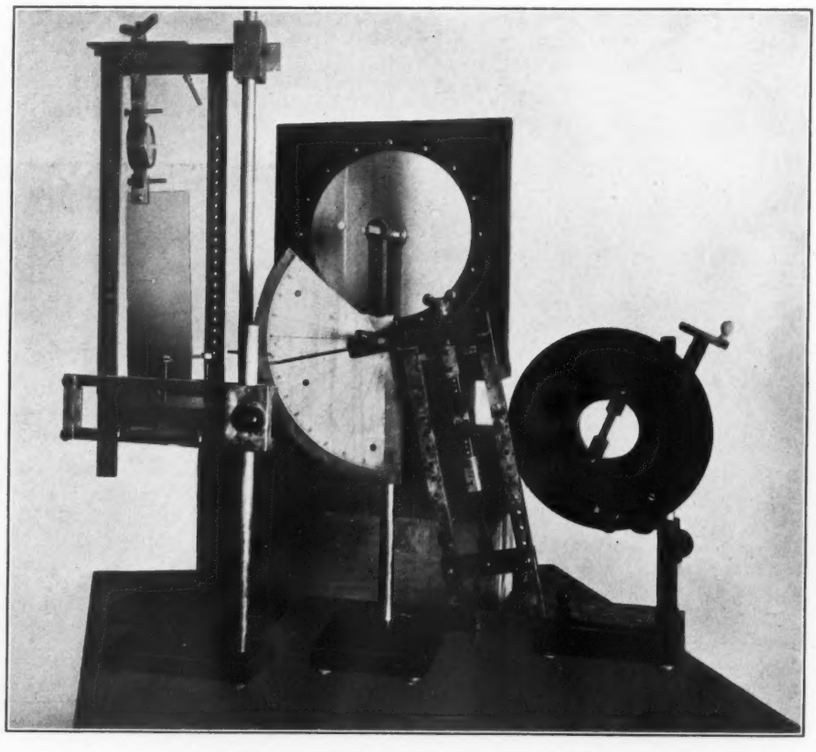
2. If in a similar beam of rectangular section, we cut *an elliptical hole*, whose major axis is perpendicular to the direction of the pull, the stress is, as in the previous case, concentrated near the boundary of the discontinuity; the maximum value of the stress occurs at the point of the boundary where the tangent to the ellipse is parallel to the direction of the pull.

The values of the stress at the boundary of the hole are given (4) by Fig. 7, (p. 84) where we see that the maximum stress is equal to four times the mean stress and that the compression at the end of the minor axis (90°) of the elliptical hole is equal to the mean stress.

The value of the maximum stress, at the point where the tangent to the ellipse is parallel to the direction of pull (0°), is, as has been mathematically shown (5), a function of the ratio of the lengths of the two axes. If we admit that a crack may be considered as an elliptical discontinuity such that one of the axes becomes very small, the fact that a crack usually keeps on extending, even if the member is only slightly stressed, is explained by this high stress concentration due to the

(4) Diagram 7 is taken from: "The effects of holes, cracks and other discontinuities in ships plating," by E. G. Coker and A. L. Kimball, Jr. (Trans. Inst. Naval Architects, London, 1920.)

(5) "Stresses in a plate due to the presence of cracks and sharp corners," by C. E. Inglis. (Trans. Inst. Naval Architects, London, 1913.)



FRAMES USED FOR STRESSING SMALL MODELS

high value of the ratio of the major axis to the minor. Fig. 8 shows the high concentration of stress occurring at the end of such a crack; and the way, well known to engineers, to limit the extension of a crack, which is starting, is to replace the ends of the elliptical discontinuity by a circular one, where the ratio of the axes is equal to one: by drilling two circular holes, we get an image as shown by Fig. 9, corresponding to a more uniform distribution of the stresses and consequently to smaller stress concentration. The replacement of the elliptical crack by two elliptical holes whose axes are normal to those of the crack has been shown to be still more advantageous.

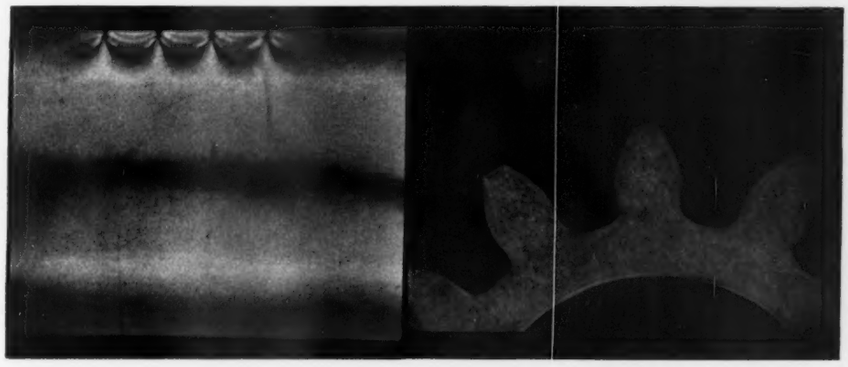


FIG. 21
FOUR PARALLEL SCRATCHES AT THE SURFACE OF A BENT BEAM

FIG. 25
A XYLONITE MODEL OF A GEAR WHEEL

Isoclinic Lines

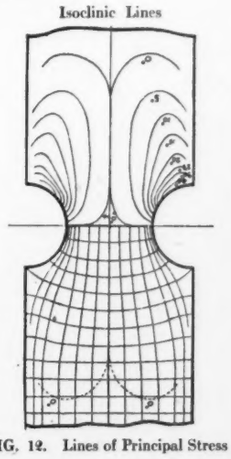


FIG. 12. Lines of Principal Stress

3. If again in a similar beam, we cut out at both sides two symmetrical *semi-circular notches*, we get the image shown by Fig. 10.

A V-notch (Fig. 11) shows a somewhat similar stress distribution. For the semi-circular notch, the lines of principal stress (6) are shown by Fig. 12. Fig. 13 (p. 84) shows the values of the principal stresses for a notch of ¼ inch radius across the minimum cross section, and Fig. 14 (p. 84) the values of the tangential stress along the semi-circular notch and along the outside parallel edge. Again here the value of the maximum principal stress is about 30% higher than the mean stress through the minimum cross section. Figs. 15 to 20 inc. (p. 85 and 96) give the values of the principal stresses (7) across the minimum cross section and along the edge of the lateral discontinuity, respectively for the V-notch, for the U-notch and for the Charpy notch (impact tests), in a beam of rectangular cross section under longitudinal pull.

(6) Diagrams 12, 13 and 14 are taken from: "Photo-elastic measurements of the stress distribution in tension members used in the testing of materials," by E. G. Coker. (Proc. Inst. Civil Eng., London, 1921.)

(7) Diagrams 15 to 20 are taken from: "Stress concentrations due to notches and like discontinuities," by E. G. Coker and Paul Heymans, (British Assoc. Report, 1921) and "Etude par la photo-elasticimetrie de la distribution des surtensions dues a certaines discontinuites dans les pieces soumises a traction," by Paul Heymans. (Academie Royale de Belgique, Classe des Sciences, Brussels, 1921,)

The maximum stress depends on the radii of the curves at the bottom of the notch. If for the V-notch this radius becomes small, we have a scratch, as those shown by Fig. 21, which represents the effect of four parallel scratches at the surface of a bent beam. The higher maximum stress which is revealed by this photo-elastic analysis shows why a scratch, which is surely not an appreciable reduction of the active section, weakens considerably a member, especially if it is made of brittle material, such as glass or hardened steel, in which practically no redistribution of stress occurs between the elastic limit and the breaking point.

B. Some specific engineering problems

A great number of problems occurring in structural engineering, such as bridge construction, design of transmission towers, naval architecture, etc., either are or may be decomposed into two-dimensional elastic problems, and therefore, however hyperstatic and indeterminate they may be, are capable of being solved, as completely as desired, by the photo-elastic methods.

1. Fig. 22 (p. 96) for instance shows the model of *a simple truss*, which has been used for experimental purposes (Prof. Coker's laboratory) under different combinations of applied loads. The stress analysis at the different joints is of course the most interesting. The image obtained by photo-elastic analysis (8) shows immediately that the

(8) "La Photo-elasticimetrie, ses principes, ses methodes et ses applications," by Paul Heymans, (Bull. Soc. Belge Ing. et Ind., Brussels, 1921), p. 113.

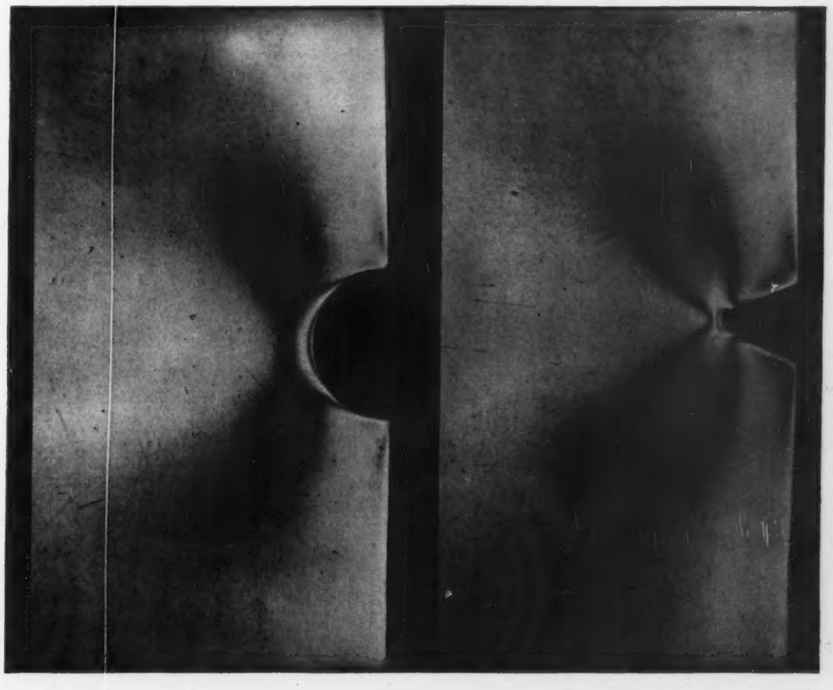


FIG. 10
Lateral Semi-Circular Notch

FIG. 11
Lateral V-Shaped Notch

LATERAL NOTCHES IN A BEAM OF RECTANGULAR CROSS SECTION UNDER LONGITUDINAL PULL

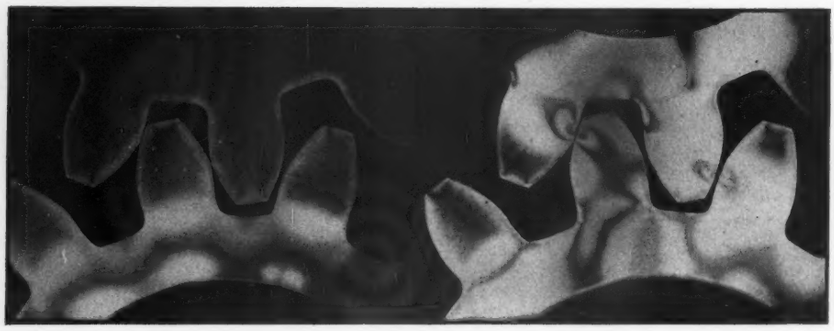


FIG. 26
A Xylonite Model under inside pressure due to the Shrinking on the Shaft

FIG. 27
The Xylonite Model when the Torque is applied

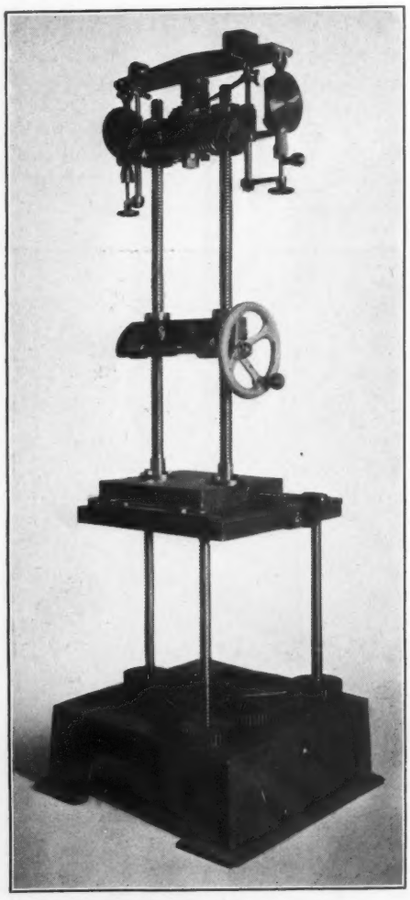
PHOTO-ELASTIC STUDY OF GEAR WHEELS AND PINIONS

members are not, as assumed in calculations, under uniform stress. In fact, the image shows the actual state of stress at each point, due as well to the so-called primary as to the secondary stresses.

2. Application of photo-elastic analysis has been made successfully to *bridge construction.*

An interesting case is the one made and published by M. Mesnager, Chief Engineer of the Department of Bridges and Roads in Paris (9).

Fig. 23 (p.100) shows a general view of the bridge and Fig. 24 represents the models and special frames used.



SPECIAL PHOTO-ELASTIC TENSION AND COMPRESSION MACHINE DESIGNED BY A. L. KIMBALL, JR.

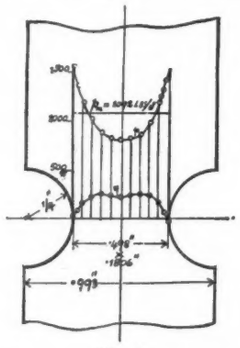


FIG. 13
THE PRINCIPAL STRESSES ACROSS THE MINIMUM CROSS SECTION

It is interesting to quote M. Mesnager (10), "We have used photo-elastic analysis in the laboratory of the Ecole des Ponts et Chaussées (Paris) in order to check the calculations made for a bridge of ninety-five meters span, which was to be built over the Rhone at la Balme. . . . The amount of calculations made was considerable, and, while checking them, certain errors in the methods and in the figures had been detected. Complementary calculations, sent in as corrections of the first one, extended into a book of forty-eight pages. Were there no other errors which had been overlooked? Besides, for such an important construction in reinforced concrete, was it not advisable to make certain preliminary experimental verifications? Tests made in the laboratory on small metal models had given some interesting results, but most of them were incapable of interpretation.

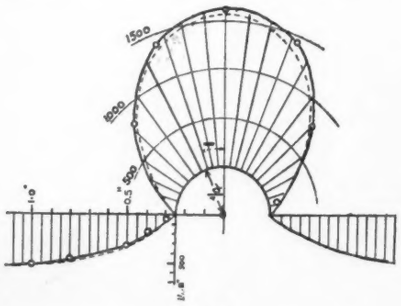


FIG. 14
THE TANGENTIAL STRESS ALONG THE BOUNDARY OF THE NOTCH AND ALONG THE OUTSIDE EDGE

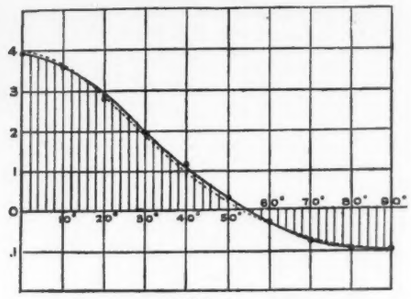


FIG. 7
THE TANGENTIAL STRESS ALONG THE BOUNDARY OF THE ELLIPTICAL HOLE

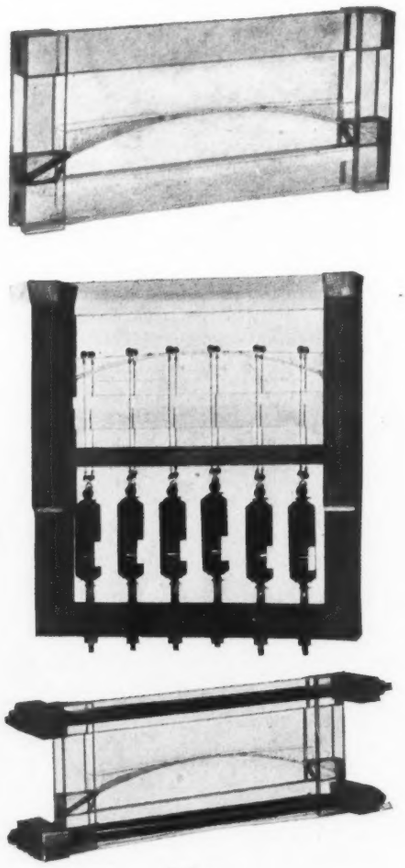


FIG. 24
THE GLASS MODEL AND THE FRAMES USED BY MESNAGER IN HIS PHOTO-ELASTIC ANALYSIS OF THE LA BALME BRIDGE

(9) "Utilisation de la double refraction accidentelle du verre a l'etude des efforts interieurs dans les solides," by M. Mesnager. (Annales des Ponts et Chaussees, Paris, 1913.)

(10) Translated from M. Mesnager, loc. cit., p. 178 and p. 135.

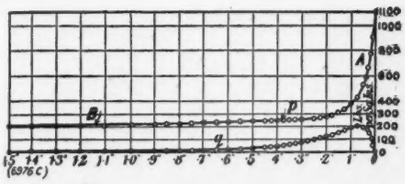


FIG. 15
THE PRINCIPAL STRESSES ACROSS THE MINIMUM CROSS SECTION (V-Notch)

On the other hand, reliable experimental results were asked by the Acting Commission before decision. It is in those circumstances that, in order to come to a solution, I had a glass model of the bridge made. This work, which cost less than one-thousandth of the price of the construction, finally enabled us to get the necessary verifications. . . . The study of the reduced glass model enabled us to obtain accurate results in less than twenty days, whereas the calculus had required a time considerably longer without giving the same reliability."

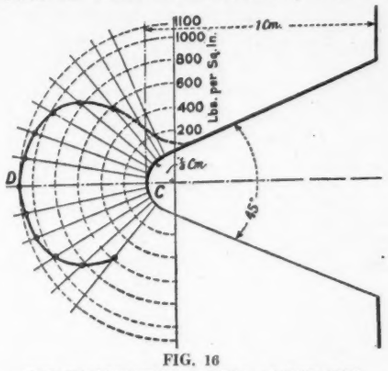


FIG. 16
THE TANGENTIAL STRESS ALONG THE BOUNDARY OF THE NOTCH

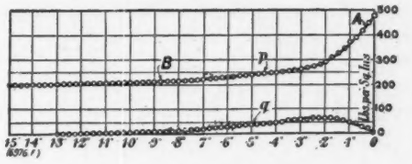


FIG. 17
THE PRINCIPAL STRESSES ACROSS THE MINIMUM CROSS SECTION (U-Notch)

However at the time when this application of photo-elastic analysis was made, only the maximum stresses, which always occur at the edges where one of the principal stresses vanishes, could be obtained and, furthermore, Mesnager used glass, which gave him serious difficulties for the building of the models.

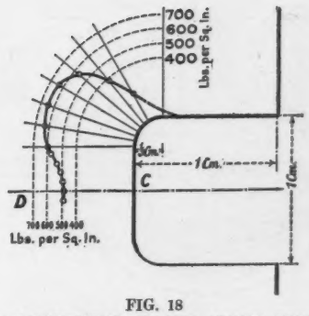


FIG. 18
THE TANGENTIAL STRESS ALONG THE BOUNDARY OF THE NOTCH

3. In the photo-elastic laboratory here at Technology an extended study of stress distribution in certain special *gear teeth and pinions* is now being carried out.

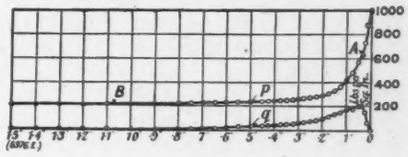


FIG. 19
THE PRINCIPAL STRESSES ACROSS THE MINIMUM CROSS SECTION (Charpy Notch)

(*Continued on page 96*)

THE NEW SHIP CRANE FOR THE NAVY

(*Continued from page 71*)

entire crane. There is no manual labor connected with these operations. All of the motors are governed by automatic control and the operator is required only to turn the small handles of his master controllers to make the giant do his bidding.

The back of the rotating platform will be counterweighted to compensate for the eccentricity of the extreme weights which the crane will handle. For this purpose it is proposed to use about four hundred tons of the old armor plate removed from the ship. This will first be placed in position and then imbedded in concrete to secure it in place.

For the operation of the various functions of the crane, direct current at two hundred and twenty volts will be supplied by a generating plant to be installed in the ship. Leads from this generator will pass through the center pin and terminate in contact rings from which the current will be collected by sliding contact shoes.

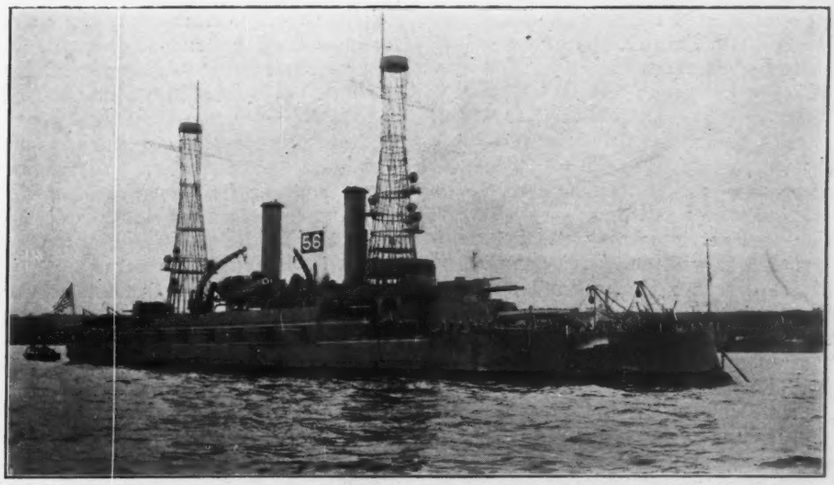
The general arrangement and principal dimensions of the crane are shown in the accompanying cut. Each of the main hoist blocks will handle a load of one hundred and twenty-five tons at a radius of one hundred and one feet and, when connected by the equalizer, the maximum load of two hundred and fifty tons at the same radius has a vertical range from forty feet below the deck to one hundred and three feet above the deck. The minimum radius of the main hoist, with the jib in its highest position, will be seventy-two feet.

The auxiliary hoist will have a capacity of forty tons with a maximum reach of one hundred and seventy-four feet horizontally. At a radius of one hundred and fourteen feet the vertical range will be from forty feet below to one hundred and thirty-five feet above the crane foundation. This hoist will operate at full load with the jib in any position.

It is interesting to note that the outer end of the jib, when in its highest position, is about one hundred and ninety feet above the water, and with the jib in its lowest position the extreme end is one hundred and two feet beyond the side of the ship.

Identical motors will be used for all operations of the crane. They will be of enclosed mill type, series wound and

(*Continued on page 88*)



UNITED STATES BATTLESHIP KEARSARGE
This vessel is to be converted into Crane ship No. 1

FAREWELL, SANS ADVICE

How weary must our departing seniors be of all the advice which has been, and still is, coming their way! Untold quantities of advice: at banquets, lectures, class dinners; in sermons, on class day and at commencement; always the advice of some older, more experienced man to the young hopefuls before him.

More than useless, in these columns, would be any addition to that never-ending stream; more than superfluous any admonitions regarding alumni spirit and loyalty to Alma Mater. As a prominent industrial leader has said, what more can be done for a man just out of college, than to place before him—opportunity?

The departing senior class is entering the industrial and business world at a particularly auspicious time. The economic cycle is on the upward swing; therefore it is the fervent hope of THE TECH ENGINEERING NEWS, that to each and every man there will come before long, his opportunity, and that in grasping it he will be taking the right step towards the realization of his cherished aim in life.

PROFESSOR WILSON

It was with a feeling of regret, mingled with a sense of personal loss, that we received the announcement of the retirement of Professor Wilson from the Institute Faculty.

He had earned a high place for himself in the hearts of Tech students. Those who have studied their freshman physics under him will long remember that experience as one of the most pleasant of their collegiate career. His lectures were at all times clear, instructive, and yet interesting and entertaining. Yet it was not merely because of his ability as a teacher, and still less because of his extraordinary record as a scholar, that he was so respected and revered. Rather it was on account of his always keen appreciation of the students' difficulties, and his consequent deep sympathy for the students that he was so endeared to them.

We were proud to know and to be able to say that we had such a man for the head of our Physics Department. And frankly that pride is a little stung, a little wounded, by the realization that he is leaving us to join the faculty of another educational institution.

Tech will not seem the same without him. Still it has been said that "Nothing is permanent but change," and we must believe that this sort of change is better for society as a whole if not for Technology as a unit. At any event we can but wish him the greatest success in his new work and hope that he will remember us as kindly as we are sure his former students here will remember him.

IN THE RIGHT DIRECTION

It is encouraging, in these days of conflict between the technical and the cultural sides of engineering education, to read that at the University of Michigan the engineering courses have been made five years in length, and that the ultimate aim is to further extend these courses over a period of six or seven years, all for the purpose of introducing more subjects of a non-technical nature during the first few years at college.

Such a step on the part of one of our leading engineering institutions constitutes a striking development of several recent tendencies in engineering education. First, the addition of one or more years of general training, preceding the strictly technical work, seems a frank recognition of the tendency towards regarding engineering as a fit subject for graduate, not undergraduate study. And in turn, this elevation of engineering to the level of graduate study corresponds closely to the recognition of engineering as a profession, on a par with the older professions of law and medicine. In each case, the service performed by the individual for the community is great; therefore it is just to demand for engineers a training commensurate with the service they are called upon to bestow. And such training is not to be had in the concentrated four-year courses of today.

The study of law or medicine does not begin until the student has completed a four-year undergraduate course, designed to prepare him for better citizenship, for a truer conception of the basic principles of his chosen profession, and for a better understanding of the application of those principles to professional problems, later in life.

With engineering, it is true, the preliminary work in mathematics and the sciences is a direct continuation of work begun in the secondary school; therefore, it might be unwise to interject a period of years involving a total cessation of work of this nature. Still, the need for non-technical subjects is there: psychology, philosophy, logic, economics, English — all these have a vital bearing on the success of any man, professional or otherwise, and they can and must be included in engineering college courses. The remedy is longer courses. And, incidentally, such amplification of the engineering training might well serve to eliminate, along with the waster of American collegiate resources, his equally unfortunate brother—the "dumbbell."

THE CITY OF CONTRASTS

Many of us come to Tech from far distant places. Our undergraduate days are spent in or near Boston, and when we leave, it is safe to say that every man will carry away with him some definite impression of the city which has been his temporary home. "Quaint," "picturesque," "cultured," "interesting," "commonplace," "beautiful," "ugly," "snobbish," "democratic," — such adjectives as these will come to mind. In spite of obvious contradictions, all may be applied with accuracy, for after all is not the "Hub" a city of amazing contrasts?

In the realm of education, art and music, Boston holds an enviable position, yet she tolerates political conditions of the worst variety. Among her daily papers may be found the most refined example of American journalism —and the yellowest of scandal sheets as well. We admire Boston's beautiful parks and public buildings; we wonder at the shabbiness of her railroad terminals and industrial districts. We cross the Charles one day on the majestic new West Boston Bridge rearing its granite arches gracefully over the lower basin; we return via the dilapidated

structure known as Harvard Bridge, an offense alike to eye and ear. From the broad avenues of the Back Bay it is but a step to the narrow, tortuous lanes of the business district, "cowpaths" of a day gone by. And weather! What discourse upon Boston would be complete without reference to the caprice of the elements in this vicinity? Here is variety to the nth degree! One day in April, we swelter in the heat of summer; the next, we find the landscape white with winter's snows. Truly, if "variety is the spice of life" applies to weather, then may Boston claim the lion's share!

But it is certain that, varied as are the impressions of each departing senior, each will have benefited, in a perhaps intangible way, from his sojourn in this center of art and learning. For Boston is, of all American cities, a city where people learn to think; with all her faults and idiosyncrasies, Boston has not permitted the prevalent American spirit of "money-grabbing materialism" to deaden appreciation of the higher things of life. Though her politics be as crooked as her ancient lanes and byways, though she be a haven for aliens from foreign lands, yet does Boston proudly retain her leadership in true culture, her steadfast desire "to know the best that is known and thought in the world." In the soundness of her educational methods and in the quality and diversity of her entertainments, Boston provides an atmosphere which must invariably exert a beneficial, broadening influence upon all who come within its sway.

NATIONAL PLANNING

Only in recent years has our government taken steps to oversee the economical and scientific development of American forests and other natural resources, which were being exploited in a wasteful and ruinous manner. Proper and systematic usage of our natural assets will benefit the whole nation, and before many decades, may be absolutely necessary to support the ever-growing population.

For over five years, Mr. Warren H. Manning, a landscape designer of wide experience, has studied the question in great detail. His plan and suggestions received the hearty endorsement of Franklin K. Lane, former Secretary of the Interior, and other men of experience in the same department. Mr. Manning advises that the country be blocked out into areas best suited for certain kinds of development, as the production of special crops, and that the best waterways, road sites, and even airplane routes be investigated. He lays special stress on the value of transcontinental roads, which should facilitate cheaper transportation of raw materials to industrial centers. Coördination between the road network, the railroad, and water transportation should greatly reduce the cost of shipping and moving supplies. With increased population food will become scarcer; so production in a given area of the crops best fitted for that section will greatly increase the available supply of foodstuffs.

But ten per cent of our available water power is used at the present time. As cheap power is a paramount consideration, extensive development of this factor alone would be a great boon to the nation's industries. It is calculated that if only fifty per cent of our water resources were used, the electricity derived could supply the whole nation with power at the present time.

In short, the whole plan advocates an exhaustive study of our country—its natural resources, rainfall, waterways, wind currents, and all other factors affecting human activity. To carry out this work Mr. Manning proposes a nonpartisan National Plan Commission, whose duty it shall be to inform our citizens how resources can best be used; to carry out a searching study of all resources and economic factors of our country; and to introduce the necessary legislative measures.

On a much reduced scale this plan is successfully carried out in many large cities. The importance of the whole question, before the appearance of Mr. Manning's study of the situation, caused the formation of several societies of scientific men for investigation along these lines. Inquiry of this kind is of immense practical benefit; and if the work is carried out in the manner laid down in Mr. Manning's survey, it will mean a new era in the development of national resources.

PROFESSIONAL SOCIETIES

In the issue of *Power* for April 4, Mr. F. R. Low makes the following remarks under the title, "Go to Society Meetings." The thought seems so good and so well expressed that we are passing it along.

"No man liveth to himself alone.

"In one way or another all our acts and interests are bound up with those of others. And the more we do, the more useful we are in the world, to the greater degree is this true.

"A wide circle of acquaintance, a host of friends is the best kind of capital a man can have. It not only adds to his value and earning capacity, but it puts joy into life.

"The engineer has been accused of a lack of sociability, of shutting himself in with his own thoughts and problems and wonderings.

"If he lived more in the open, if he sought contact with his fellows, he would find them wrestling with the same problems and wondering and thinking about the same subjects. And they would be interested in his solutions; his own thinking would be clarified by the process of expression, and he would find help and suggestion in their handling of their difficulties and inspiration in their discussion.

"The most helpful friends that one can have are those of his own vocation, when that vocation is professional or at least involves some mentality; and the best place to make and meet friends of this sort is at the meetings of associations and organizations of such people.

"The redeeming feature of associations that are disappointing in realization of their declared object of educational uplift, is that they do bring their members together in a relationship that, by reason of their common vocational interest, has something broadening and humanizing and satisfying about it. If the attendant at such meetings brings away no addition to his store of knowledge, no inspiration for his thinking or his work, he is at least richer in the friends that he has made."

MEETINGS AND CONVENTIONS

American Order of Steam Engineers—Annual convention and exhibition at Philadelphia, June 5-9.

National Association of Stationary Engineers—New York State Convention at New York City, June 8-10.

Illinois State Convention at Chicago, June 9-10.

New England Convention at Springfield, Mass., July 12-14.

American Railway Association, Mechanical Division—Annual meeting in Atlantic City, N. J., June 14-21.

National District Heating Association—Annual convention at Cedar Point, Ohio, June 20-23.

Society of Automotive Engineers—Summer meeting at White Sulphur Springs, W. Va., June 20-24.

American Institute of Electrical Engineers—Annual convention at Niagara Falls, Ontario, June 26-30.

American Society for Testing Materials—Twenty-fifth annual meeting in Atlantic City, N. J., June 26-July 1.

American Institute of Electrical Engineers—Pacific Coast convention in Vancouver, British Columbia, August 8-11.

National Safety Council—Annual Safety Congress in Detroit, Michigan, August 28-September 2.

THE NEW SHIP CRANE FOR THE NAVY

(Continued from page 85)

will have a rating of one hundred and ten horse power for one-half hour. Eight of these motors forming the power equipment of the crane, will be distributed; one to each of the main hoists, one to the auxiliary hoist, one to the auxiliary trolley, two to the rotating, and two to the luffing mechanisms. An electrically operated disk brake will be applied to each motor, so arranged as to set when the current is cut off. Flexible couplings will be used to connect the motors to their pinions.

The motor with its flexible coupling, pinion, brake and bearings, is mounted on a cast bed plate to form a standard power unit, which will be identical for each of the mechanisms. The motor pinions and their gears will be of herringbone type, with teeth ground and hardened.

Each of the one hundred and twenty-five ton main hoist blocks will be suspended by eight parts of two-inch steel cable, reeved in a double four-part system, the cable ends passing over deflecting sheaves to the machinery house where they are connected to separate drums geared to a standard power unit. The two main hoists will be so arranged that they may be coupled together for simultaneous use.

The forty ton auxiliary hoist block will be suspended from the trolley by eight parts of one and one-quarter inch steel cable reeved in a double four-part system. The two cables will be anchored to the inner end of the jib, and after reeving through the trolley and block, will pass around sheaves at the outer end of the jib and back to the auxiliary hoist mechanism, the ends being attached to two drums geared to a standard power unit.

On account of the inclination of the jib, a greater amount of power is required to move the trolley toward the outer end of the jib than in the reverse direction. A double two-part system of one and three-quarter inch cable will be used for the outward travel and two one inch tail ropes will be provided.

(Continued on page 94)

A Remarkable Sale of High Grade

Drawing Instruments

We have been fortunate in securing from the manufacturers a large assortment of the best made DRAWING INSTRUMENTS.

For the opening of the Massachusetts Institute of Technology classes we are offering these sets to STUDENTS at prices lower than have prevailed for years.

All the standard makes are included in this lot.

Let us show you our complete drafting outfit for students.

Our Stock is Complete

SPAULDING-MOSS CO.

42 Franklin Street, Boston, Mass.

Just a Step from Washington Street

Present this advertisement and you will be entitled to a discount of 10 per cent on your purchases

Seniors

Send The Tech Engineering News for one year beginning with the October 1922 issue at the price of $1.50

Name .....

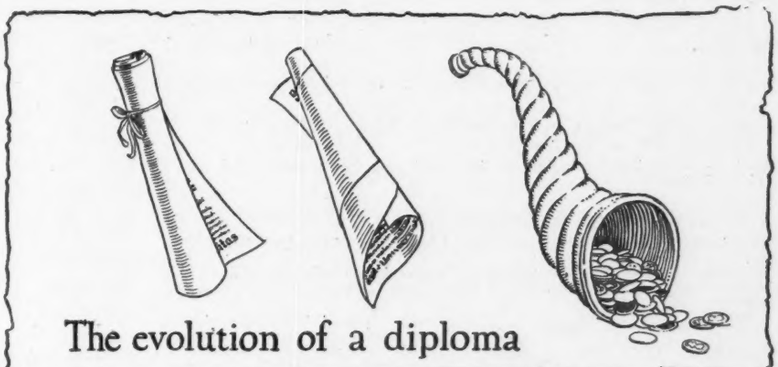
Address .....

"What magazine do you read?"
Do you realize that your employer will judge your

LOYALTY—INTEREST—VALUE

by the magazines which you read in school and which you will read outside?

Do you know that *The Tech Engineering News* will furnish you with the most valuable engineering news available and will also keep up your connection with the Institute—a bond which it is never wise to sever.



The evolution of a diploma

There's hard work ahead before you can play this horn

Ordinarily a diploma doesn't turn into a horn of plenty overnight. This truism sums up a good deal of the advice you seniors may expect to hear.

People who know best don't want you to be impatient. They say you can't expect to run things from the start. Are they right?

To answer that question, look back to the time when you were freshmen. How many in your class won any worthwhile campus honors that year?

And why should they? What kind of a varsity team would freshmen make?

Well, that's the way many people feel about seniors hoping to run the business world next year.

The ambition to lead is all right. But—in business as at college—first must come the try-outs. Then, if you plug hard, the scrub team. Then, when you show you've "got the stuff," the varsity.

But through it all remember this: the harder you work on the scrub, the sooner you'll make the varsity and the better you'll cover your position.

Work hard. Keep fit. Don't get downhearted. Remember, the team will need new blood some day—maybe next game. When your chance comes, be ready.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

Western Electric Company

Since 1869 makers and distributors of electrical equipment

Number 19 of a series

WOOD PULP

(*Continued from page 76*)

type. One very large sulphite mill operates electrolytic cells for the production of bleaching liquor, preparing solid caustic soda as a by-product.

The type of apparatus most generally favored at present is the vertical cathode, diaphragm cell with anodes and leading-in rods of graphite. Covered chambers of cylindrical or rectangular plan form the anode compartment which is provided with an inlet for brine and an exit for chlorine.

The cathode may be surrounded by a gas-tight compartment from which hydrogen may be piped for use if desired. Hydrochloric acid may be made by uniting the chlorine and hydrogen from such cells in a furnace followed by a cooling and absorption system.

The shape, size, capacity, material and relative position of the structural elements of the cells have all undergone an evolution which has finally resulted in large capacity units requiring relatively small floor area and operating at low voltage and high current efficiency and having a long life and low up-keep charge. The soda mill thus has immediately at hand the means of supplying its requirements for both the chemicals needed for treatment of wood and fibre in a very convenient form.

The necessity of containers for the storage of bleaching powder is obviated and the disagreeable features of preparing bleaching liquor from such powder which were formerly endured do not exist.

Moreover, for those plants favorably situated as regards power, there is a distinct economic gain in utilizing the electrolytic method of making caustic and bleaching liquor as an adjunct to the manufacture of one of the impor-

(*Continued on page 92*)

SAVE FROM 20% TO 50%

of the time now required for posting your business transactions to cards and loose leaf forms, by using

THE VISIBLE POSTINDEX EQUIPMENT

for carrying your same records on four-page, folded forms of standard sizes and larger.

These forms give double the usual space for keeping records, offer a line of twice their width for Visible Indexing and, being made of heavy linen ledger paper, are more serviceable than cards.

Records carried on this equipment may be exposed in a few seconds, and in a position for reading, writing upon or offsetting — without removal from the panels. No more misfiled cards. The most compact and rapid file on the market — 1000 items require less desk space — with panels upright — than the telephone book; and tab-cutting will increase this to 4000 or more, for the same base space.

Cabinets may be had with side-hinged folding panels, so compact that a file of 12,000 items — that can be increased to 96,000 by tab-utting — may be placed on a five-foot desk within working reach of one clerk. T.E.N. uses our cabinet or their subscription records.

Be sure to mention T.E.N. when writing for information as we are very desirous of bringing this superior equipment to the attention of highly trained technical men, and such mention will secure more than our usual careful attention to your inquiry.

Endorsed and recommended by prominent industrial engineers and C.P.A.'s. Send for a catalog — or better send for a salesman, for your own benefit.

DURABLE — VISIBLE — EFFICIENT — RAPID

THE COSTMETER CO. 1000 WASHINGTON STREET, BOSTON, MASS
Telephone Beach 4243

Young Men, Attention!

A New Feature

Radio Department

In The

Boston Evening Transcript

Mr. E. L. Bowles
of the
Massachusetts Institute of Technology

will conduct a daily column dealing with this interesting new science.

It will include both elementary and advanced instruction, news and anything else of interest to its followers.

Read the Daily Radio Column in the Boston Transcript

Industrial Printing

THE MURRAY PRINTING COMPANY is located at Kendall Square, Cambridge, in its own modern and commodious building, with a plant that is efficient in every detail. The firm has been established one-quarter of a century and handles the printing of catalogues, periodicals and technical books. The firm's list of customers includes many large manufacturers and publishing houses of New England.

Always ready to intelligently coöperate with you on your printing requirements

THE MURRAY PRINTING COMPANY
KENDALL SQUARE, CAMBRIDGE

THE RIGHT KIND OF PAPER USED IN EDUCATIONAL PUBLICATIONS
BRINGS THE RIGHT KIND OF RESULTS

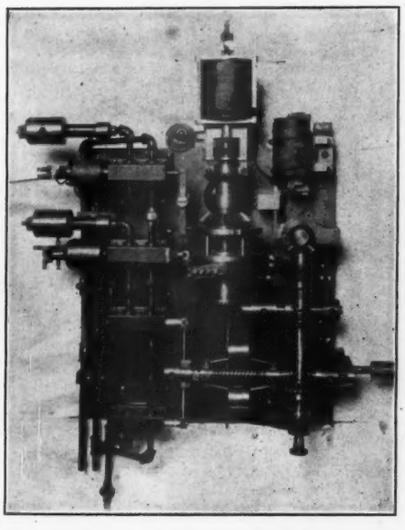
S & A Coated Book

TRADE MARK
Reg. U. S. Pat. Off.

Distributors of Coated, Cover and Bond Papers to the Educational Trade

STONE & ANDREW, INC.
280 Devonshire Street, Boston, Mass.

New York Springfield Worcester Providence New Haven



Brake Setting Apparatus Installed on the Locomotive

"Perfection"

will be meaningless unless the railroads can operate at all times with

"Safety"

With service in the preservation of life as his only motto Meyer D. Minnick has devoted his talents and energy for the past twenty years to the development and PERFECTION of this train-control system.

He welcomes communications or personal inspection.

M-V TRAIN CONTROLLER COMPANY

NEWARK, NEW JERSEY

DISPLAY ROOM 153 SUMMER STREET BOSTON, MASS.

The
American Chimney
Corporation
of New York

Chimneys

BOSTON CHICAGO
PHILADELPHIA
CLEVELAND

New England States Manager
GEORGE W. STETSON
141 Milk Street
Boston, Mass.

147 FOURTH AVENUE
NEW YORK CITY

IDEALS

Youth has ideals that jaded and careworn age has often long forgot.

It has ever been our ambition to preserve the freshness of our craft and to satisfy the strict demands of those who cling to the ideals of their youth.

Perry & Elliott Company
146 Summer Street
Boston, Mass.

BEMIS BROTHERS BAG CO.

Cloth and Paper Sacks

INDIANAPOLIS	ST. LOUIS	HOUSTON	KANSAS CITY
MEMPHIS	BOSTON	BEMIS, TENN.	WINNIPEG
OMAHA	NEW ORLEANS	MINNEAPOLIS	BROOKLYN
SEATTLE	SAN FRANCISCO	PEORIA	

ALBERT FARWELL BEMIS, '93, President

WOOD PULP

(*Continued from page 90*)

tant fibrous materials for paper manufacture.

The bleaching liquor thus formed after settling to remove sludge is pumped to "bleachers" where it is brought into contact with the pulp at suitable temperature and with agitation.

For anodes some form of carbon has usually been employed, though the expensive metal, platinum, has been used in experimental units and in at least one American plant.

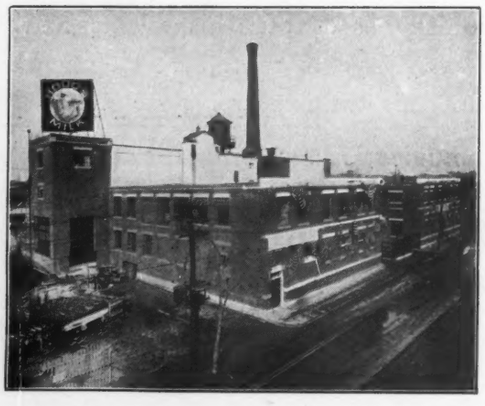
Anodes of graphite transformed from amorphous carbon in the high temperature of the electrically heated furnace are one of the great aids to the electrolytic industry developed by Acheson. In the form of plates, rods and slabs Acheson Graphite is a very adaptable material for anode construction. It, moreover, resists the erosive influences present in the interior of the cell for long periods of time.

Cathodes have generally been constructed of some form of iron or steel in the form of grids, perforated plates or woven fabric. Mercury has also been employed as a cathode in several well-known types. The mercury cathode type possesses the advantage of delivering a pure grade of caustic soda.

For diaphragms asbestos paper is the most economical material to employ. The cathode grating, or wire gauze, supports or reinforces the diaphragm against the pressure of the electrolyte. Electrical connections are made directly to anode extensions, or leading-in rods passing through the cell-top, or cover, and to the cathode, or tank, forming the cathode chamber. The operation of such cells is of a very quiet and apparently simple nature.

Brine prepared from salt by pumping water through a column of rock salt crystals, and freed from alkaline earth salts by treatment with soda ash, with subsequent neutralizing of excess soda with hydrochloric acid, is delivered to

(*Continued on page 98*)



WILLIAM T. REED CO.

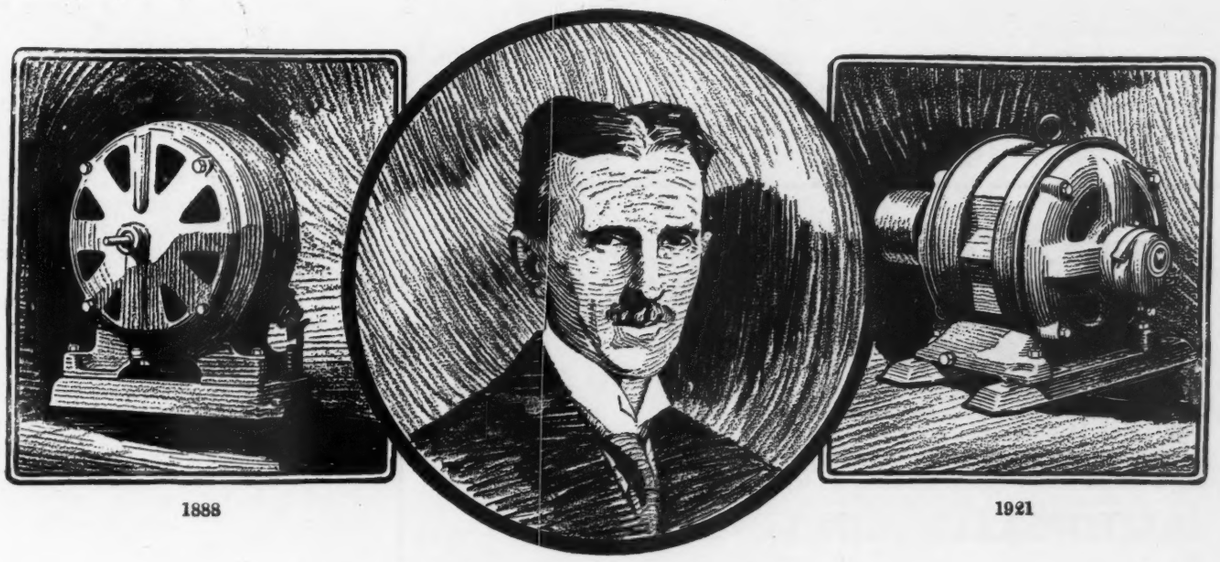
Building Construction

201 DEVONSHIRE STREET, BOSTON 9, MASS.

INDUSTRIAL CONSTRUCTION
SLOW BURNING OR FIREPROOF

FORMERLY

NEW ENGLAND CONCRETE CONSTRUCTION COMPANY



1888 1921

Nikola Tesla

THE NAME of Nikola Tesla will always be associated with the invention and earlier developments of the induction motor. In fact, at one time this type of apparatus was known almost exclusively as the "Tesla" motor.

Tesla devised this motor back near the beginnings of the electrical business, when practically everything was built by "cut and try" methods, and none of the accurate analytical processes of later days had been developed. It may be said broadly that Tesla knew two fundamental facts—first, that if a magnet were moved across a sheet of conducting metal, it would tend to drag this metal along; and,—second, that the *effects* of such a moving magnet could be produced by suitably disposed polyphase currents acting on a *stationary* magnetic structure.

Perhaps others, at that time, also knew these two facts, but if so, apparently they knew them only as two isolated facts. Tesla considered them *in combination* and the result was the Tesla motor, or what is now known broadly as the "induction motor." These two facts, in combination, represent a fundamental conception, and all of the many millions of horsepower of induction motors in use today throughout the world, are based upon these two fundamentals.

Naturally, Westinghouse, having fought single handed to advance the alternating current system, was supremely interested in the new type of motor. What if the new motor did require polyphase circuits, while all existing circuits were single phase? What if it did require lower frequency than any existing commercial circuits? These were merely details of the future universal alternating system. The important thing was to obtain an ideally simple type of alternating current motor, which Tesla's invention offered. Tesla furnished the fundamental idea.

He and his associates, working for Mr. Westinghouse, proved that thoroughly operative induction motors could be built, provided suitable frequencies and phases were available. What matter if they did not produce an operative commercial system at the time? What matter if it needed the powerful analytical engineers of later date to bring the system to a truly practicable stage—men with intimate constructive knowledge of magnetic circuits—men on intimate terms with reactive coefficients and other magnetic attributes totally unknown to Tesla and his coworkers? In time the motor was made commercial, and it has been a tremendous factor in revolutionizing the electrical industry.

Probably no one electrical device has had more high-power analytical and mathematical ability expended upon it than the induction motor. The practical result has been one of the simplest and most effective types of power machinery in use today. Thus Tesla's fundamental ideas and Westinghouse's foresight have led to an enormous advance in the world's development.

Westinghouse

W

WESTINGHOUSE ELECTRIC

SHIP CRANE

(*Continued from page 88*)

The two large ropes will be anchored at the outer end of the jib and lead around sheaves in the trolley, then around the end of the jib and back to the trolley mechanism, where they will be anchored to two large winding drums. The tail ropes will lead directly from the trolley to a drum of one-half the diameter of the large ones, thus compensating for the two-part system on the outer end. All of the drums are geared to a standard power unit, as in the case of the other mechanisms.

The two independent power units for rotating the crane are located at each side of the platform and each geared to one of the bevel pinions which mesh with the gear ring attached to the foundation. There is no mechanical connection between these two units, equalization of the rotating loads being produced by the characteristics of the motors, which holds them in electrical balance. In case of accident to either motor the other is capable of revolving the crane at reduced speed.

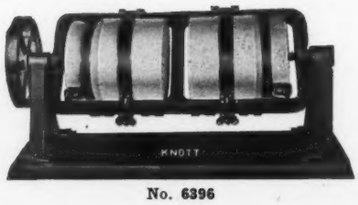
Luffing of the jib, up or down, will be accomplished by varying the distance between the back frame and the elbow of the jib. For this purpose, four large screws will be used, two having right hand and two left hand threads. These screws will be arranged in pairs at each side of the jib, one right hand and one left hand being placed end to end and coupled together at the center, the ends passing through nuts supported on trunnions in the back frame and the jib. These screws will be turned by gears attached to the center couplings. On account of the extreme angle through which the jib is luffed, there is great variation in the distance between the nuts, and in order to prevent underside deflections in the screws when fully extended, a luffing strut will be introduced. This strut will be pin-connected to the jib at a point midway between the hinge pins and the nuts, and its upper end will be supported on trunions at the center of the screw coupling. In addition to supporting the screws, this strut also forms a support for the luffing mechanism, which will consist of two standard power units geared to the screw coupling.

The screws will be fifteen inches in diameter, of alloy steel, heat treated, and will have buttress threads four inches in pitch. The nuts will be over four feet in length, of manganese bronze, and will be supported in steel trunion castings.

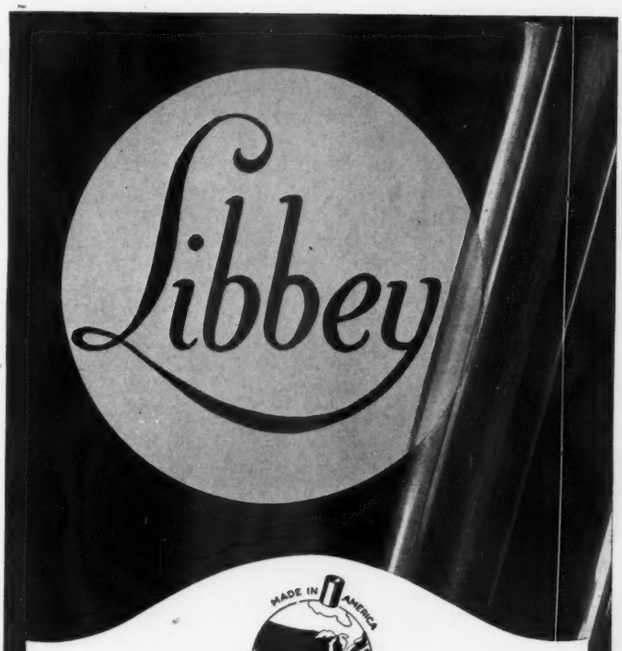
GENERAL WELDING & EQUIPMENT CO.
G.W.&E.C.
74 BROOKLINE AVENUE, BOSTON, MASS
WELDING AND CUTTING EQUIPMENTS
AUTOMATIC CUTTING MACHINES

DWIGHT P. ROBINSON & COMPANY
INCORPORATED
ENGINEERS AND CONSTRUCTORS
125 EAST 46TH STREET
NEW YORK
CHICAGO YOUNGSTOWN DALLAS LOS ANGELES MONTREAL

IN EQUIPPING YOUR NEW LABORATORY
Send your list of furniture, apparatus, and reagents to us for quotation
Complete industrial laboratory equipments a specialty
L. E. KNOTT APPARATUS COMPANY
MANUFACTURERS OF SCIENTIFIC INSTRUMENTS
79-83 AMHERST STREET CAMBRIDGE 39, MASS.



No. 6396
Laboratory Ball Mill for Pulverizing cement, coal, lime, and other material
Send for Catalog 26C



MADE IN AMERICA
LIBBEY GAUGE GLASS
WORTHY OF THE WORLD'S RESPECT

GAUGE GLASSES

High and Low Pressure

The traditions of a century of quality manufacture are squarely behind Libbey Gauge Glasses—an American product worthy the respect of the world.

Libbey High Pressure Glasses are guaranteed unconditionally to be uniform in size, to withstand steam pressures of 400 pounds, as well as sudden and radical changes in temperature; to remain crystal clear and transparent in service.

Libbey High Pressure Gauge Glasses have passed rigid railroad and other tests even more severe with a perfect score. They are made with fused ends.

Libbey Low Pressure Gauge Glasses are absolutely uniform in size and of the very finest quality; guaranteed to withstand pressures up to 200 pounds.

We welcome inquiries for prices or literature

THE LIBBEY GLASS MFG. CO., Toledo, O., U.S.A.

Massachusetts Institute of Technology
School of
Chemical Engineering Practice

A graduate school with stations established in industrial plants located at Bangor, Maine, Boston, Mass., and Buffalo, New York, where the field of chemical engineering is studied systematically on large-scale apparatus and where instruction is given in the application of chemical and chemical engineering theory to practice.

The total number admitted to the School is limited and the students, studying and experimenting in small groups, receive individual attention.

Before admittance to the School of Chemical Engineering Practice all students must have adequate preparation in chemistry and engineering. The able student can complete the requirements for the Master of Science Degree in one and a half years.

During the past two years representatives of twenty-four colleges have attended the School of Chemical Engineering Practice and these men comprised over one half of the attendance.

For further details address:

R. T. HASLAM, Director, Room 2–131

School of Chemical Engineering Practice

Massachusetts Institute of Technology, Boston, Mass.

No headaches

where Atlas Non-Freezing is used

Atlas Non-Freezing Explosive *will not cause headaches* from handling. Think what this means to blasters who have endured for years the sickening headaches caused by certain kinds of dynamite.

Atlas Non-Freezing is an "all-'round" explosive. It is made in different grades to suit various conditions; it has abundant power and is safe to handle.

ATLAS POWDER CO.
WILMINGTON, DELAWARE

A PROPER EXPLOSIVE FOR EVERY BLASTING REQUIREMENT

Burton-Furber
Coal Co.

—

Sole Retail Agents

Crozer-Pocahontas Coal

Selected Grades of

ANTHRACITE COAL

—

50 CONGRESS STREET
BOSTON, MASS.

WIRELESS TELEPHONE
AND
RADIO APPARATUS
Including
COMPLETE SETS

CLARK & MILLS ELECTRIC COMPANY
ELECTRAGISTS
75 Newbury Street, Boston
Telephones
Back Bay 365 and 366 and 8295

1444 Massachusetts Avenue Cambridge
Telephone University 1169

Everything Electrical

PHOTO-ELASTICITY

(Continued from page 85)

Fig. 25 (p. 83) shows one of the xylonite models when no force is applied.

Fig. 26 (p. 84) gives the colored image obtained for the structure in position on the shaft.

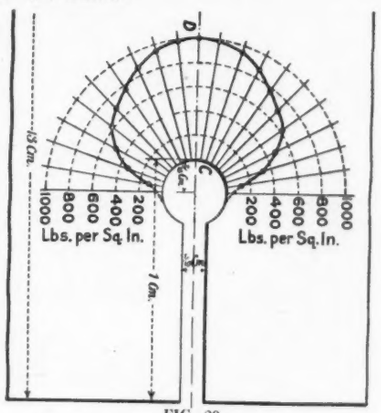


FIG. 20
THE TANGENTIAL STRESS ALONG THE BOUNDARY OF THE NOTCH

Fig. 27 (p. 84) gives the colored image when the torque is applied.

The work being still in progress, it would be premature to discuss results.

When one has examined the stress distribution in a certain number of

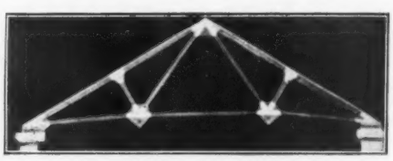
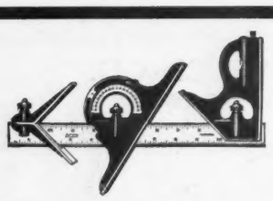


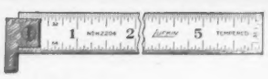
FIG. 22
A XYLONITE MODEL OF A SIMPLE TRUSS

members entering into a structure, he is impressed with the number and nature of the approximation employed in engineering problems. Empirical calculations of that kind, — and practically all contain simplifying assumptions, — may be relied upon only when they have been sufficiently checked by experience, — if, in other words, the factor of safety has been for each particular case adequately adjusted.

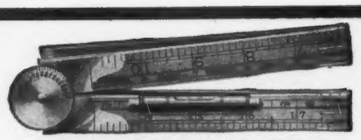
For new types of construction, or where it becomes of importance to distribute the structural material in the most economical manner, these

(Continued on page 100)





LUFKIN



MECHANICS TOOLS
TAPES—RULES

RELIABLE, PROGRESSIVE LINES
Not only made from the best of materials, but having improved, exclusive features

SEND FOR CATALOGUE THE LUFKIN RULE CO. SAGINAW, MICHIGAN New York
London, England Windsor, Canada

INDUSTRIAL BUILDINGS SHOULD BE WELL LIGHTED.

From the employer's viewpoint, the big difference between men who work out of doors and those who perform tasks inside the building, is the factor of light. Daylight furnishes sufficient illumination outside during the daytime working hours for men to pursue their tasks efficiently and safely. But the proposition of getting enough daylight into the interior of industrial buildings, requires some thought.

It is not a difficult problem by any means, and any employer can take advantage of daylight and utilize it for lighting his building during the daytime, if he desires. It is an excellent light, especially suitable for the eyes, reducing eye strain and eye weariness to a minimum, and has the great economic advantage of costing nothing.

To utilize daylight to the utmost, we must first provide means for allowing daylight rays to enter the interior of buildings in sufficient quantity—namely, proper and adequate windows and skylights. Many excellent instances of buildings designed with a due regard to the importance of daylight lighting can now be seen in many of our industrial cities. Such buildings present the appearance of being practically all windows—"window walled," as they are termed—and this type of daylight construction is coming rapidly into favor, because it constitutes a more healthy building for large numbers of employes, both from the lighting and ventilation standpoints.

Among those who have constructed this type of modern industrial building may be mentioned: The Shredded Wheat Co., Gillette Safety Razor Co., Lyon & Healy Piano Co., H. J. Heinz Co., Corona Typewriter Co., Skinners Macaroni Co., Grape Juice Co., Dodge Bros., Nelson Valve Co., Piston Ring Co., Remington Arms Co., and a great many others.

The Larkin Co., Philadelphia, has erected a building almost entirely glass, 85% being windows, and the Loomis Breaker, operated by the D. L. & W. R. R. Co., Nanticoke, Pa., is literally a glass house, being 93.5% of glass. The new buildings of the Winchester Repeating Arms Co. have an average glass area of 58%.

An investigation covering 18 buildings constructed by the Aberthaw Const. Co., Boston, shows that the average window area is 57.5%.

These figures indicate how important the subject of lighting is now considered by employers of industrial labor, and how well the idea has been carried out by the architects and engineers, in order that all parts of a building may receive sufficient daylight. But, in addition to providing ample window space, there is another factor which is equally important, and that is, equipping the windows with the proper glass.

The bright direct rays of the sun should not be permitted to strike the eye, and we must provide a means for reducing the glare to rays which will not be too bright. This is accomplished by glass especially manufactured for industrial windows, known as Factrolite. This glass possesses the property of breaking up the intense rays of the sun and diffusing the light into the interior of the building in proper portions, solving the problem of sun glare.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

Iron and Emery Cast Together!

FERALUN
Anti-Slip Treads

Approved by Underwriters Laboratories & Casualty Liability Insurance Companies

When making details or writing specifications it is well to have in mind some of the important applications of **Feralun.**

Coal Hole Covers
Area Covers
Gutter Plates
Elevator Door Thresholds
Freight Elevator Landings
Floor Plates
Ramps
Stair Treads { Superimposed / Inserted / Complete
Trench Covers
Shipping Platforms
etc. — etc.

For tread surfaces of more distinction and beauty and particular qualities, bronze and aluminum are used instead of iron as the metal into which the abrasive is cast.

Send for Samples

AMERICAN ABRASIVE METALS CO.
50 CHURCH STREET, NEW YORK CITY

Good Equipment is Worthless Without Good Lubrication

THE efficiency of machinery can never be greater than the efficiency of its lubrication.

Lubricants which hurry equipment to the scrap pile — lubricants which require constant attention and application — lubricants whose continual dripping spells undue waste and fire risk are not efficient.

Cutting out waste and increasing output are the big problems of the present day. Proper lubrication solves both problems and

KEYSTONE
TRADE MARK Reg. U.S. Pat. Off.
GREASE
THE MASTER LUBRICANT

is the proper lubricant.

It's saving time, labor, equipment and money in many of America's greatest industrial plants. Its density is unaffected by extremes of heat and cold. It is insoluble in water and impervious to outside chemical attacks.

Write for our new booklet "Ten Good Reasons for Using Keystone Grease."

Keystone Lubricating Co.

Executive Office and Works: PHILADELPHIA, PA., U. S. A.

Established 1884

New York, Boston, Pittsburgh, Chicago, Detroit, St. Louis, Denver, San Francisco, Minneapolis, Montgomery, Kansas City, Memphis, Omaha

Agencies in Principal Countries Throughout the World

When reports are continually announcing that the limit of our petroleum supply will soon be reached, we welcome the statement of C. P. Bowie, of the United States Bureau of Mines that processes have been developed for the economical extraction of gasoline from asphaltum, oil shale, tar, etc.

The newest small motor vehicle is a car weighing only one hundred and seventy-five pounds and is driven by a two and one-half horse power motor wheel. It is claimed the car is capable of running eighty miles on a gallon of gasoline and a quart of oil at a speed of from two to thirty miles per hour.

WOOD PULP

(Continued from page 92)

the anode compartments of the cells in a nearly saturated condition.

The perviousness of the diaphragm and the hydrostatic pressure of the electrolyte are regulated so that a volume bearing a fixed relation to the area of the diaphragm and to the magnitude of the current flowing continuously passes through the diaphragm. During such passage one-half, or a larger percentage of the salt in the solution is decomposed, so that the effluent solution emerging from the cathode compartment contains a corresponding fraction of caustic soda. The chlorine separated at the anode is conducted away to absorption towers where it is brought in contact with showers of milk of lime.

The cathode effluent solution is concentrated in multiple effect evaporators arranged for crystal separation, the separated salt is freed from caustic and redissolved for return to the cells. The concentrated caustic solution is united with the caustic resulting from boiling the reclaimed soda ash from the soda pulp mill recovery system with lime.

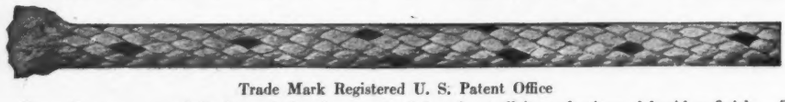
A large telescope lens has recently been cast for the Trye Observatory of Seattle. The speculum weighs ten tons and is probably the largest telescope glass in the world and is manufactured under special annealing process.

CHAUNCY HALL SCHOOL
ESTABLISHED 1828
THE SCHOOL THAT CONFINES ITSELF EXCLUSIVELY
TO THE PREPARATION OF STUDENTS
FOR THE
Massachusetts Institute of Technology
553 BOYLSTON STREET
BOSTON, MASS.
FRANKLIN T. KURT
Principal

Starkweather & Broadhurst, Inc.
BOSTON
SALES ENGINEERS
for
Power Plant Apparatus

Established 1870 Incorporated 1890
THE WARREN SOAP
MANUFACTURING COMPANY
Textile Soaps
77 SUMMER STREET BOSTON, MASSACHUSETTS

Stanhope Auto & Machine Co., Inc
GREIG AND PATTERSON
STARTING LIGHTING IGNITION
TELEPHONE B.B.6076
USED CARS
REPAIRS
BOSTON 17 MASS.
GENERAL AUTO
35 & 37 STANHOPE ST.

SAMSON SPOT SASH CORD

Trade Mark Registered U. S. Patent Office
Made of extra quality cotton yarn, carefully inspected and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.
CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST
SAMSON CORDAGE WORKS **88 Broad Street, Boston 9, Mass.**

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY aims to give thorough instruction in Civil, Mechanical, Chemical, Mining, Electrical and Sanitary Engineering; in Chemistry, Electro-chemistry, Architecture, Physics, Biology and Public Health, Geology, Naval Architecture and Engineering Administration.

To be admitted to the Institute, the applicant must have attained the age of seventeen years and must pass examinations in Algebra, Plane and Solid Geometry, Physics, Trigonometry English, French or German. Certificate of preparation in two units of a series of elective subjects is also required. The requirement in History may be met by the presentation of a school record of certificate grade. A division of these examinations between different examination periods is allowed. In general a faithful student who has passed creditably through a good high school, having two years' study of French and German or three years of French or German should be able to pass the Institute examinations.

Graduates of colleges, and in general all applicants presenting certificates representing work done at other colleges, are excused from the usual entrance examinations and from any subjects already satisfactorily completed. Records of the College Entrance Examination Board, which holds examinations at many points throughout the country and in Europe, are also accepted for admission to the Institute.

Instruction is given by means of lectures and recitations, in connection with appropriate work in the laboratory, drawing-room or field. To this end, extensive laboratories of Chemistry, Physics, Biology, Mining, Mechanical Engineering, Applied Mechanics, and the Mechanics Arts have been thoroughly equipped, and unusual opportunities for field-work and for the examination of existing structures and industries have been secured. The coöperative course in Electrical Engineering and that in Chemical Engineering Practice afford an unusual opportunity to combine a technical training with a direct contact with the industries.

The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degree of Master of Science, Doctor of Philosophy, and Doctor of Science are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories and in the Research Laboratories of Applied Chemistry, Electrical Engineering, Industrial Physics and Physical Chemistry.

The tuition fee, not including breakage in the laboratories, is $300 a year.

For catalogues and information, address

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
CAMBRIDGE 39, MASS.

Pinkham & Smith Co
Prescription Opticians

Only Boston Dealer
in
lumière autochrome
plates—chemicals
and accessories

Two Stores
292-294 Boylston Street 13 Bromfield Street

PHOTO-ELASTICITY

(Continued from page 96)

approximate calculations are often inadequate. It may be, as in airplane design, that the purpose is to lighten the structure, or as in the designs of steel and concrete constructions, to reduce the amount of idle material.

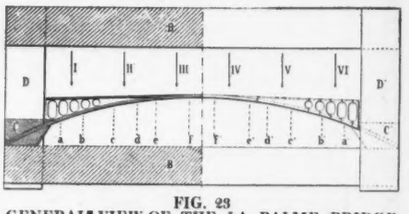


FIG. 23
GENERAL VIEW OF THE LA BALME BRIDGE

By the use of photo-elastic methods these objects can be obtained without compromising safety. The constantly recurring accidents caused by failures of mechanical devices and structures, emphasize the need of a method of analysis such as is now offered through the photo-elastic investigations.

The photo-elastic method of investigation has been developed principally by Dr. E. G. Coker of University College, University of London, with whom the writer has studied and to whom he is greatly indebted for inspiration and suggestions concerning this later work. The author also acknowledges the assistance of Mr. John T. Norton in taking many photographs including the autochrome color plates, used in this article, and of Mr. Carl Selig in cutting the xylonite models and the General Electric Company in loaning a portion of the apparatus.

Economy Morse Chain Grease

Many of the largest and most up-to-date textile mills, rubber manufacturers, and water companies, etc., are installing the Morse Chain Drives.

To obtain the very best of lubrication, we recommend our special consistency for the following reasons:

It is a pure, Pennsylvania refined mineral oil lubricant, containing absolute'y no fillers.

It will not bind the sprockets, nor will it drop off.

It has sufficient "body" to stay between the chain and sprockets.

It retains its original consistency during all seasons of the year.

It is made by grease lubrication specialists.

Try five pounds at our expense.

ESTABLISHED 1909
ECONOMY LUBRICATING COMPANY
SOLE MANUFACTURERS
HARRY H. ATKINSON, Proprietor
WORKS AND OFFICE
5 TEMPLE STREET
CHARLESTOWN 29, BOSTON, MASS.

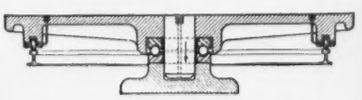
STANDARD INSTRUMENTS OF PRECISION

C. L. BERGER & SONS
37 WILLIAMS STREET
Established 1871 BOSTON, MASS.

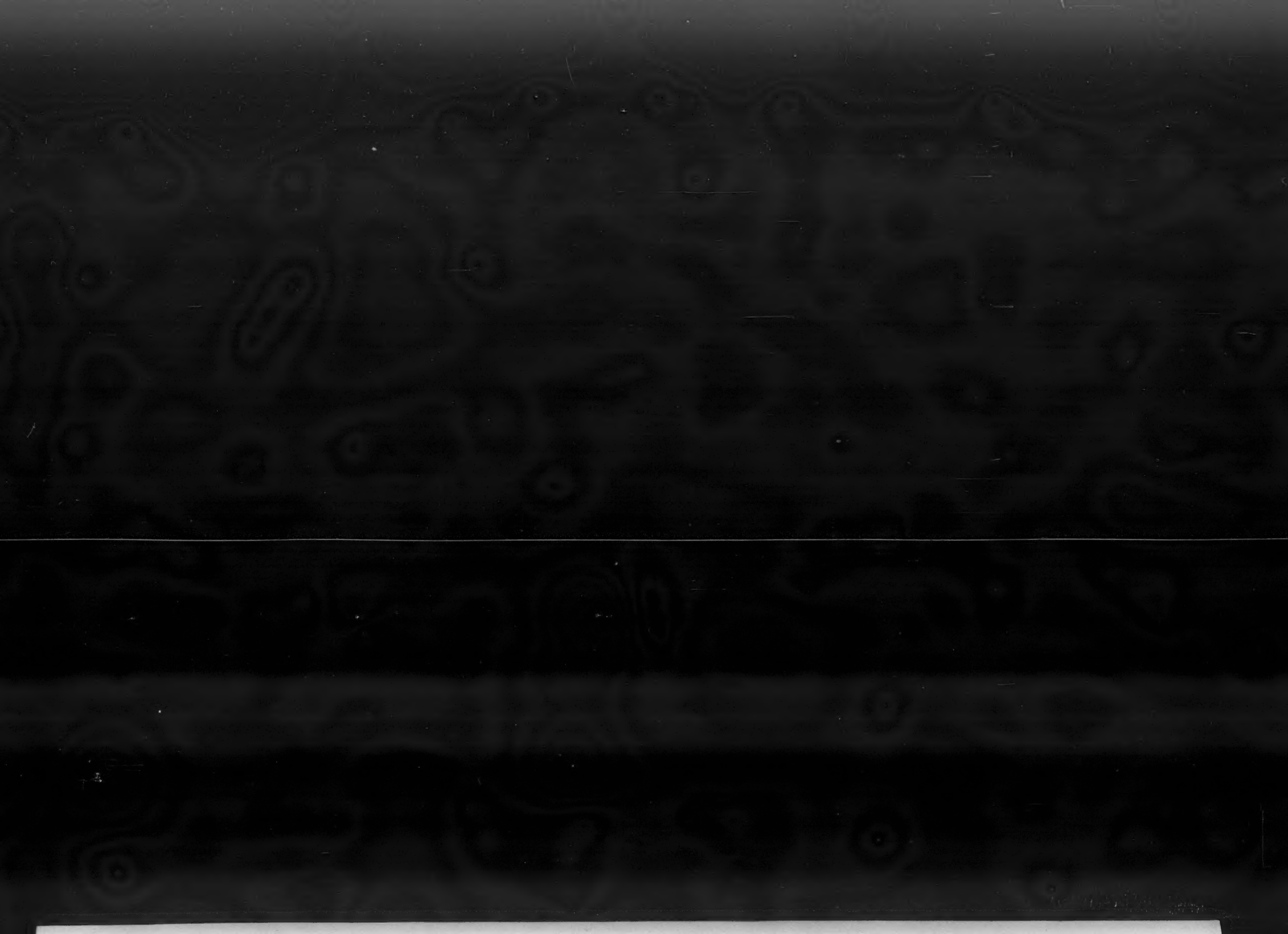
Turn Tables move easier
on
AUBURN THRUSTS

Turn Tables and other slow moving machine parts are turned easily under the heaviest loads when Auburn Ball Bearings are installed to reduce the starting friction. Mail sketch of your problem and get the Auburn Answer. Data sheets sent on request.

Steel, Brass and Bronze Balls

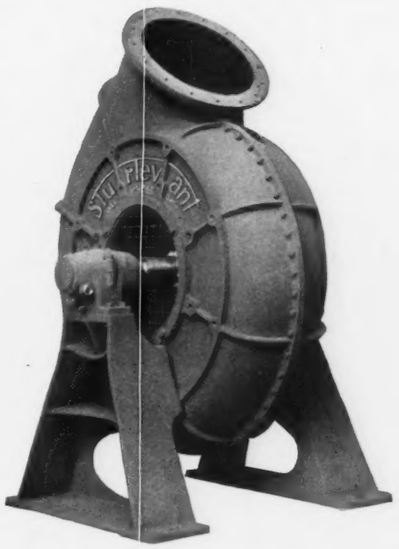


AUBURN BALL BEARING CO.
44 Elizabeth Street
Rochester, New York, U. S. A.



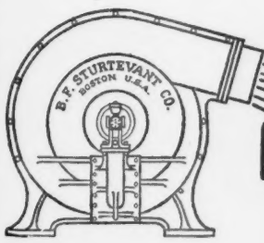
Pressure Blowers for Smelting

IRON has been in use for probably nearly three thousand years. Much of the first iron used was doubtless of meteoric origin and was used for ornaments and trinkets. The iron first used for tools and weapons was probably made from the more easily worked iron ores with wood or charcoal for fuel. The smelting operations must have been very slow and inefficient. The residue from these early smelting operations was at a later period used in England for nearly one hundred years as one of the chief sources of iron ore.



The early smelters learned from experience that by properly shaping their fires, increased draft and quicker smelting was possible. The arrangement of stone hearths with some kind of a chimney to increase the draft was a gradual development.

Much of the iron melted in cupolas even within the last two hundred years has been done with charcoal fuel and with natural draft. As the demands and uses for iron became greater it was necessary to melt iron more quickly and cheaply. The cupola was gradually improved and blowers of both the centrifugal fan type and rotary types came into use. Modern production has continually called for higher air pressures and for a while the pressure seemed too high for the simple belt-driven fan. Then came improvements in fan construction and high-speed motors for direct connection until today either the positive type of blower or the centrifugal fan type are built for any desired pressure. The preferable type to use depends on local conditions, the experience of the operator, and the source of power available. The results of the melt are not dependent on the type of blower used, but on the accurately controlled air blast and the reliability and efficiency of the blower.



Sturtevant

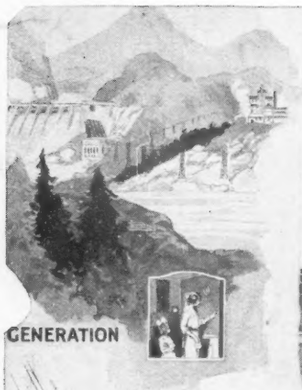
REG. U.S. PAT. OFF.

PUTS AIR TO WORK

HYDE PARK, BOSTON, MASS.

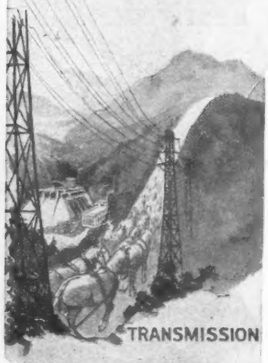
SALES OFFICES IN ALL PRINCIPAL CITIES

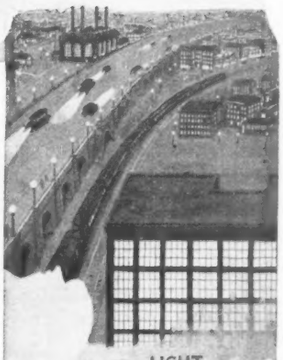
646



HEADQUARTERS
GENERAL ELECTRIC COMPANY
SCHENECTADY N.Y.

AIR PURIFICATION





LIGHT

A Gateway to Progress

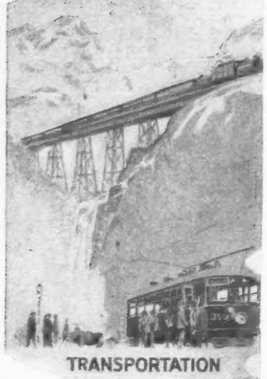
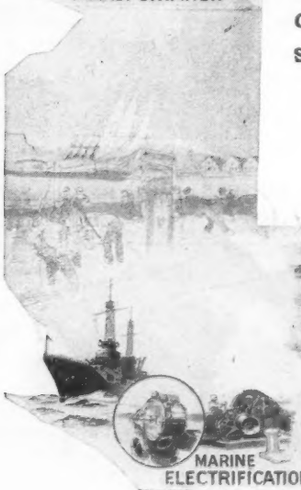
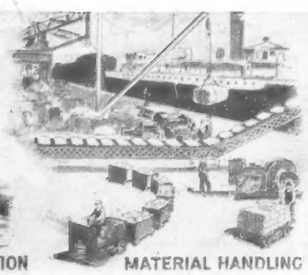
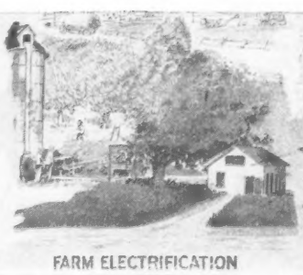
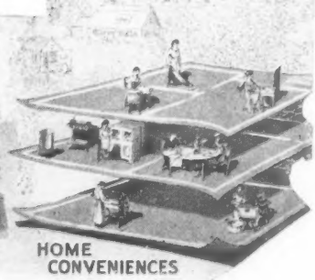
There it stands—a simple forty-foot gateway but unlike any other in the entire world. Through it have come many of the engineering ideas that have made this an electrical America.

The story of electrical development begins in the Research Laboratories. Here the ruling spirit is one of knowledge—truth—rather than immediate practical results. In this manner are established new theories—tools for future use—which sooner or later find ready application.

The great industries that cluster around Niagara Falls, the electrically driven battleships, the trolley cars and electrified railways that carry millions, the lamps that glow in homes and streets, the household conveniences that have relieved women of drudgery, the labor-saving electrical tools of factories, all owe their existence, partly at least, to the co-ordinated efforts of the thousands who daily stream through this gateway.

General Electric Company
General Office Schenectady, N. Y.

95-511-H



HEAT